

PREFACE

This volume, the Remedial Investigation for the Former DuPont Works Site (the Site), is the first of a series presenting information developed as part of the Final Remedial Investigation, Risk Assessment, and Feasibility Study (RI/RA/FS) for the Site, located in DuPont, Washington. Preparation of these reports was stipulated in the July 1991 Consent Decree, between the Washington State Department of Ecology (Ecology) and the potentially liable parties, (PLP) Weyerhaeuser Company (Weyerhaeuser) and E.I. DuPont de Nemours and Company (DuPont). Per the Consent Decree, the reports were developed in accordance with the Model Toxics Control Act (MTCA) cleanup regulations. Draft RI/RA/FS reports were completed in 1994 (Hart Crowser 1994d, 1994e, 1994f) and submitted to Ecology. The Final RI/RA/FS reports have been developed to satisfy comments on the draft reports and to accurately reflect existing conditions and planned future land use at the Site. These reports incorporate agreements reached with Ecology between 1991 and 2001.

A brief description of each report follows:

- **Remedial Investigation.** The purpose of this RI was to collect, develop, and evaluate sufficient information regarding the Site to enable the completion of the RA and FS. The RI characterizes the nature and extent of contamination in the context of past activities at the Site. The RI report presents the analytical data that have been collected at the Site. The data are presented for each RI area; these areas were defined on the basis of historical manufacturing and production operations at the Site.
- **Risk Assessment.** The RA evaluates Site conditions in relation to planned future land uses at the Site. The RA identifies soil cleanup concentrations and presents the methods used to derive Site-specific soil concentrations that are protective of human health and ecological receptors. These cleanup goals are compared to Site constituent concentrations in order to identify the areas that require additional evaluation in the FS.
- **Feasibility Study.** The FS evaluates alternative potential cleanup methods designed to meet the remedial action objectives. The FS report provides information for Weyerhaeuser and DuPont to recommend alternatives for remediation of selected areas, including both no action and action alternatives. Ecology will evaluate the FS and select the remedial measures it believes are appropriate in the Cleanup Action Plan. Weyerhaeuser and DuPont will complete the needed detailed design and implementation of the remedy selected by Ecology.

EXECUTIVE SUMMARY

The purpose of this Remedial Investigation (RI) is to collect, develop, and evaluate sufficient information regarding the Former DuPont Works Site (the Site) to characterize the nature and extent of contamination in the context of past activities at the Site (Figure 1-1). This RI report presents the analytical data that have been collected at the Site. The data are presented for each RI area (Figure 1-2 and Table 1-1), as defined on the basis of historical manufacturing and production operations at the Site.

PROPERTY HISTORY

The Site property was originally used by Native Americans. In the 1830s, Europeans settled in the area and built Fort Nisqually in the northern portion of the Site. Ten years later, the Fort was rebuilt at a location adjacent to but outside the eastern edge of the Site.

E.I. DuPont de Nemours and Company (DuPont) acquired the property in 1906 and constructed an explosives plant and the historical village of DuPont as a company town for plant workers. DuPont continued to manufacture explosives until the mid-1970s, when it closed the manufacturing operations and sold the property to the Weyerhaeuser Company (Weyerhaeuser). Weyerhaeuser and its subsidiary Weyerhaeuser Real Estate Company (WRECO) still own approximately 2,500 acres in the area that they named Northwest Landing. Northwest Landing is a planned community within the City of DuPont and it includes the Site. WRECO has begun to develop Northwest Landing on some of its lands within the City, but no development of the Site has occurred.

REGULATORY HISTORY

The Site was used for the manufacture of commercial explosives from 1909 to 1976. Production of explosive materials ceased and cleanup of the buildings began in 1976. As part of the cleanup process, asbestos was removed, salvageable materials were taken out, and structures were either burned or demolished. Actions taken at the Site subsequent to Weyerhaeuser's purchase include the following:

- In 1985, studies were conducted were concluded to determine whether hazardous substances were present.
- In 1986, a Phase I Site Survey and Review was performed was performed to identify areas of environmental concern on Site.
- In 1986, soil contamination was documented and reported to the Washington State Department of Ecology (Ecology).
- In 1987, a Phase II Site Characterization study was performed.
- In 1989, a Baseline Human Health RA was conducted.
- In 1991, Weyerhaeuser and DuPont signed a Consent Decree (No. 91 2 01703 1) with Ecology, in which they agreed to study the Site and complete an RI, RA, and FS.
- In 1994 and 1995, Draft RI, RA, and FS reports were submitted to Ecology (Hart Crowser 1994d, 1994e, 1994f).
- In 1996, Ecology approved a Cleanup Action Plan for a portion of the area (Parcel 2).

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- In 1997, Parcel 2 was deleted from the Consent Decree, and a deed requiring institutional controls to maintain the industrial use of the parcel was recorded in the Pierce County Auditor's office.
- Between 1990 and 2001, Weyerhaeuser and DuPont undertook Interim Source Removal (ISR) actions to clean up soil and/or debris at the Site, in accordance with the Model Toxics Control Act (MTCA) and the Consent Decree.

SCOPE OF RI CHARACTERIZATION

The scope of the Site RI includes sample collection, laboratory analyses, data evaluation, and presentation of sampling results from four environmental media, as follows:

- 21,933 soil sample analyses (5,182 samples)
- 1,181 freshwater sediment sample analyses (20 samples)
- 12,038 groundwater sample analyses (283 samples)
- 1,528 surface water sample analyses (344 samples)

All RI data were collected in accordance with the Site Management Plan (Hart Crowser 1992a). Only those data representing current Site conditions within the Consent Decree Boundary (CDB) have been used in this RI. Data from sampling points that were removed during ISRs have been deleted from the RI database because they no longer represent current Site conditions.

SOIL QUALITY

Sampling Approach

Soil sampling locations were chosen on the basis of historical maps, former DuPont employee information, other Site information, statistical needs, and public comments. Additional samples were collected on the basis of an evaluation of initial sampling results, to evaluate whether the lateral and vertical extent of constituents of concern had been determined. Each RI sample was analyzed for one or more constituents.

Sampling Results

The RI areas from which soil samples were collected are shown in Figure 1-2. Data from the pre-RI and RI sampling and analysis indicate that the highest constituent concentrations occur in surface soil samples collected in the vicinity of production building foundations and waste disposal locations. Constituents of concern found in the production/disposal locations are associated with activities that occurred during facility operations.

Interim Source Removals

Many ISRs were conducted at the Site between 1990 and 2001. These activities have been summarized in a series of ISR memoranda (see Section 5 for references) and include the following:

- Areas 5 and 6 drum, soil, and debris removal

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- Area 8 pipeline, tank, and soil removal
- Sympathetic detonations (Area 18)
- Dinitrotoluene (DNT)-impacted soil removal (Areas 10, 18, 25, and 31)
- Lead and miscellaneous debris removal (Areas 18/1/2/3/4, 19C, 24, 30, 31, 35, and 36, and Maintenance Buildings)
- Mercury-impacted soil removal (Area 39)
- Underground storage tank (UST) removals (Areas 20A, 20B, 38, and 39)
- Sitewide lead and arsenic hot spot removal including Area LR-68
- Lead- and arsenic-impacted soil removal around foundations and along the narrow-gauge railroad (NGRR)
- Lead- and arsenic-impacted soil removal (Sand Laydown Area)
- Lead- and arsenic-impacted soil removal (Topsoil Laydown Area)

Many of the pre-RI and RI sampling points were removed during the interim actions, and these data are no longer representative of current Site conditions. Therefore, all removed data points have been omitted from this RI.

Existing Conditions

Under current Site conditions, constituents of concern detected in Site soils at elevated concentrations are the following:

- Lead
- Arsenic
- Total petroleum hydrocarbons (TPH) (Bunker C and non-Bunker C)
- Mercury
- Trinitrotoluene (TNT)
- Benzo(a)pyrene

Other constituents have been detected in soil but, just because a constituent is detected does not mean it is above levels of concern.

Lateral and Vertical Extent

The lateral extent of the constituents detected in Site soil and debris was generally limited to production foundations and waste disposal areas, with the exception of lead and arsenic, which were also detected Sitewide, at concentrations above or near background soil concentrations. The vertical extent of constituents was generally confined to a depth of less than 1 foot in all areas except acid discharge areas, drywell locations, some production-related foundations, and disposal areas, where the vertical extent was generally limited to a depth of less than 10 feet.

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SITE GEOLOGY

The major stratigraphic units located beneath the Site are described in Section 3 and summarized in this section.

Steilacoom Gravels constitute the surficial soils of the Site and extend to a depth of about 300 feet. The Steilacoom Gravels consist of brown and gray stratified sands and gravels, with cobbles and occasional zones of siltier sand. The Steilacoom Gravels were deposited during the retreat of the final (Vashon) glaciation in high-energy meltwater channels. Below the Steilacoom Gravels is the Vashon Till.

The Vashon Till consists of a high-density, high-silt-content till that makes it a weak aquitard. The Vashon Till is underlain by the Vashon Advance Outwash, deposited by glacial rivers or streams during the advance of the Vashon glaciation. The Advance Outwash becomes finer grained with depth, typical of advance outwash deposition. Below the Advance Outwash is the Olympia Beds/Possession Drift/Whidbey Formation/Double Bluff Drift sequence (hereafter referred to as the DBD-OB sequence) (formerly known as the Kitsap Formation).

The DBD-OB sequence is a fine-grained, interglacial deposit, approximately 70 to 100 feet thick, and very heterogeneous regionally. The DBD-OB sequence is present below the Site but does not extend west of a line about 2,500 feet inland from Puget Sound. Below the DBD-OB sequence is the Salmon Springs Glaciation (formerly known as the Salmon Springs Formation), which was deposited in the glacial period preceding the DBD-OB sequence interglacial. Regional information indicates that the formation is 70 to 120 feet thick and contains zones of organic silt and till. The Sea Level Aquifer, a regionally extensive aquifer, occurs within the Salmon Springs Glaciation.

SITE HYDROGEOLOGY

Two aquifers occur beneath the Site—the shallow Water Table Aquifer extends from 20 to 105 feet below ground surface and the deeper Sea Level Aquifer is located between 160 and 215 feet below ground surface. Across most of the Site, the relatively impermeable Aquitard (formerly known as the Kitsap Aquitard) restricts vertical flow of groundwater and separates the Water Table Aquifer from the deeper Sea Level Aquifer. This aquitard is absent west of the “Cutoff” (formerly known as the Kitsap Cutoff), which is located 500 to 2,500 feet east of Puget Sound and roughly parallel to the shoreline. The “Cutoff” is the western extent of the Water Table Aquifer and the point at which the Sea Level Aquifer becomes unconfined. Groundwater in the Water Table Aquifer flows west-northwest, with local discharge via springs to upper Sequelitchew Creek. Groundwater in the Sea Level Aquifer flows west-northwest and discharges west of the “Cutoff” as seeps to Puget Sound.

GROUNDWATER QUALITY

Based on the groundwater data presented in the 1994 Draft RI report, Ecology issued a “No Active Remedial Action” letter for Site groundwater (Ecology 1996a). Long-term monitoring for DNT continues.

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DNT Data for Site Groundwater

Data from 35 rounds of combined pre-RI and RI groundwater sampling at up to 30 locations (October 1988 through March 2001) indicate the consistent detection of DNT concentrations at marginally elevated concentrations in 6 of 30 Site groundwater monitoring locations. DNT has been detected inconsistently in one additional groundwater monitoring well at marginally elevated concentrations. If detected, the range of total DNT concentrations in groundwater is from 0.019 $\mu\text{g/L}$ to 0.78 $\mu\text{g/L}$. DNT has been detected only in monitoring wells located downgradient of areas where DNT has been detected at elevated concentrations in soils (Areas 5, 18, and 31). The DNT groundwater concentrations are expected to decline over time as a result of the removal of DNT-containing soils. Based on ISR work and well data, Ecology determined that “no active remedial action” was needed and long-term monitoring at selected wells would be sufficient (Ecology 1996a).

DNT Data for Groundwater Discharging via Seeps to Puget Sound

The two seep sampling locations (Figure 3.1-1) represent discharge of Site groundwater to the intertidal area of Puget Sound. This groundwater discharge is naturally saline due to salt water intrusion, which disqualifies it as a drinking water source in accordance with MTCA. Total DNT concentrations have ranged from nondetect to 0.27 $\mu\text{g/L}$ in the 25 samples collected from SEEP 1 over the period of monitoring. DNT has not been detected in SEEP 2. All detected DNT concentrations at SEEP 1 have been at least 33 times lower than the protective surface water concentration of 9.1 $\mu\text{g/L}$. Based on this comparison, DNT in groundwater discharging from the Site via seeps to Puget Sound poses no concern to human health or the environment.

Other Constituents

In 1988, nitrate was detected in three of the Site monitoring wells. Because one of these three monitoring wells is located along the eastern (upgradient) edge of the Site, off-Site sources of nitrate (such as animal pasturing) are possible. All three wells have had relatively low nitrate concentrations since 1988. Total carcinogenic polycyclic aromatic hydrocarbon (cPAH) concentrations in groundwater have all been low. With the exception of concentrations of naturally occurring aluminum (detected in background groundwater samples), all other dissolved metals were detected at low concentrations. No other constituents of concern that were analyzed for have been detected in Site groundwater.

SURFACE WATER FEATURES

Three surface water bodies—Puget Sound, Sequelitchew Creek, and Old Fort Lake—are located within or adjacent to the Site. Puget Sound is a large saltwater body located along the western boundary of the Burlington Northern property west of the Site. Puget Sound directly or indirectly receives all groundwater and surface water discharge from the Site. Sequelitchew Creek is a perennial stream that originates in Sequelitchew Lake east of the Site and discharges into Puget Sound. In the dry season, the upper and lower reaches of the creek within the Site are dry. Old Fort Lake is a small glacial kettle lake that has no inlet or outlet. The lake is fed by groundwater from the Water Table Aquifer, and the lake level is an expression of the Water Table Aquifer.

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SURFACE WATER AND FRESHWATER SEDIMENT QUALITY

Surface Water

Constituents detected at elevated concentrations in Sequalitchew Creek and Old Fort Lake are consistent with those detected at the area background (upstream) sampling location in Sequalitchew Creek (SW-4, Figure 3.1-1) and in other rivers and streams in Pierce County.

Freshwater Sediment

None of the wide range of constituents analyzed for in sediment samples was detected at elevated concentrations. Lead was detected in Old Fort Lake sediments at low concentrations. Detected concentrations of other metals were comparable to available background freshwater sediment data for the Puget Sound region.

Based on the data presented in the 1994 Draft RI report, Ecology verbally agreed to No Further Action for all surface water and freshwater sediments within the CDB at the Site (Ecology 1996d).

Additional soil samples, groundwater samples, surface water and freshwater sediment samples, and marine sediment samples were collected outside the CDB. These data will be presented in a separate report.

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ABBREVIATIONS AND ACRONYMS

AA	atomic absorption
ACM	asbestos-containing material
ACTIVE	Active Construction
AP	area of potential concern
AST	aboveground storage tank
ATI	Analytical Technologies Inc.
CAP	Cleanup Action Plan
CDB	Consent Decree Boundary
cm/sec	centimeter per second
cPAHs	Carcinogenic polycyclic aromatic hydrocarbons
DERS	DuPont Environmental Remediation Services
DNB	1,3-dinitrobenzene
DNT	dinitrotoluene (includes 2,4-DNT and 2,6-DNT)
DuPont	E.I. DuPont de Nemours and Company
Ecology	Washington Department of Ecology
EIS	environmental impact statement
EM	electromagnetic
EPA	U.S. Environmental Protection Agency
ESM	ESM Consulting Engineers, LLC
FS	feasibility study
gpm	gallon per minute
ISD	inorganic solid debris
ISR	interim source removal
LDR	land disposal restrictions
LR	lead reference
µg/L	microgram per liter
µm	micrometer
mg/kg	milligram per kilogram
mg/L	milligram per liter
MMAN	monomethylamine nitrate
msl	mean sea level
MTCA	Model Toxics Control Act

ABBREVIATIONS AND ACRONYMS

NAX	nitroaromatic explosives (includes TNT, 2,4-DNT, 2,6-DNT, NB, DNB, and TNB)
NB	nitrobenzene
ncPAHs	noncarcinogenic polycyclic aromatic hydrocarbons
NFA	no further action
NG	nitroglycerin
NGRR	narrow-gauge railroad
OC	organochlorine
OP	organophosphorus
PAHs	polycyclic aromatic hydrocarbons, also called polynuclear aromatic hydrocarbons
PCB	polychlorinated biphenyl
PID	photoionization detector
PVC	polyvinyl chloride
RA	risk assessment
RI	remedial investigation
RU	remedial unit
SLA	sand laydown area
SVOC	semivolatile organic compound
TCLP	toxicity characteristics leaching procedure
TDS	total dissolved solids
TNB	1,3,5-trinitrobenzene
TNT	2,4,6-trinitrotoluene
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TSS	total suspended solids
UST	underground storage tank
VOC	volatile organic compound
Weyerhaeuser	Weyerhaeuser Company
WRECO	Weyerhaeuser Real Estate Company
XRF	x-ray diffraction

This section summarizes the site history, site location and physical setting, the objectives of the Remedial Investigation (RI) report, the objectives of the field investigations, and the report organization. Much of the previous investigation work conducted at the Site is summarized in the pre-RI Phase I and Phase II reports (Hart Crowser 1986 and 1987, respectively). Pre-RI work is defined as any site investigation work done prior to the start of the formal RI agreed to in the 1991 Consent Decree. It includes any sampling activities that occurred prior to 1992. The management plans for this work are provided in the RI/Feasibility Study (FS) Management Plan (Hart Crowser 1992a). Previous reports and studies are referenced or briefly summarized where appropriate.

1.1 SITE LOCATION AND PHYSICAL SETTING

The Site is located in southwestern Pierce County, within the City of DuPont. The 636-acre Parcel 1 area within the Consent Decree Boundary (CDB) is the location of the Former DuPont Works (DuPont). Parcel 1 is bordered by the Weyerhaeuser Company (Weyerhaeuser) property to the north and west, and Weyerhaeuser Real Estate Company (WRECO) property to the east and south (Figure 1-1). Burlington Northern Railroad property is adjacent to Weyerhaeuser open space to the west. Puget Sound is located to the west of the Burlington Northern Railroad property. The Parcel 1 area within the CDB is referred to as the “Site” throughout the remainder of this document.

The Site is situated on a glacial outwash plain that slopes gently to the west, toward Puget Sound. The significant features of relief across the Site are numerous glacial kettles (depressions), the east-west-trending valley of Sequatchew Creek, a small kettle lake in the southern portion of the Site (Old Fort Lake), and the steep bluff on the west. The elevation across the Site generally ranges from 200 to 225 feet above mean sea level (msl), except within the kettles, which are at an elevation of approximately 150 feet msl. The Site is generally partially cleared or forested, with intermittent clearings.

1.2 PROPERTY HISTORY

The Site property was originally used by Native Americans. European settlement began in 1832, when the Hudson Bay Company established a cabin/storehouse on nearby Puget Sound at the mouth of Sequatchew Creek, northwest of the Site (City of DuPont 1995). In 1833, the Hudson Bay Company built Fort Nisqually in an area in the northern portion of the Site. Ten years later, Fort Nisqually was rebuilt at a location adjacent to but outside the eastern edge of the Site.

DuPont acquired the Site in 1906 and constructed an explosives plant. The historical village of DuPont, Washington, is approximately 1 mile southeast of the Site. DuPont continued to manufacture explosives until the mid-1970s, when it ceased operations and sold the Site and adjacent areas to Weyerhaeuser. Weyerhaeuser and its subsidiary WRECO still own the majority of the approximately 2,500 acres in the area known as Northwest Landing. Northwest Landing is a planned community within the City of DuPont and it includes the Site. WRECO has begun to develop Northwest Landing on some of its lands within the City, but no development of the Site has occurred.

1.3 REGULATORY HISTORY

The Site was used for the manufacture of commercial explosives from 1909 to 1976. Production of explosive materials ceased and decommissioning of the buildings began in 1976. As part of the decommissioning process, asbestos was removed, salvageable materials were taken out, and many structures were either burned or demolished. Actions taken at the Site subsequent to the shutdown in 1976 include the following:

- In 1985, Weyerhaeuser initiated studies to determine whether hazardous substances were present.
- In 1986, a Phase I Site Survey and Review was conducted to identify areas of the Site that may be of environmental concern.
- In 1986, soil contamination was first documented and reported to the Washington State Department of Ecology (Ecology).
- In 1987, a Phase II Site Characterization study was performed, which characterized the type, concentration, and distribution of constituents at 38 areas on the Site.
- In 1989, a Baseline Human Health Risk Assessment (RA) was performed using results of the Phase II survey.
- In 1991, Weyerhaeuser and DuPont signed a Consent Decree (No. 91 2 01703 1) with Ecology, in which they agreed to study the Site and complete an RI, RA, and FS. The Site was divided into two main areas: Parcel 1 (approximately 636 acres) and Parcel 2 (approximately 205 acres).
- In 1994 and 1995, Draft RI, RA, and FS reports were submitted to Ecology and underwent public review.
- In 1996, based on the result of interim source removal (ISR) actions, Ecology approved a Cleanup Action Plan (CAP) for Parcel 2 that provided for no further remediation activities except for the institutional controls to maintain the industrial use of Parcel 2.
- In 1997, Parcel 2 was deleted from the Consent Decree, and the deed requiring institutional controls to maintain the industrial use of the parcel was recorded in the Pierce County Assessor's office.
- Between 1990 and 2001, while studies and negotiations were ongoing, Weyerhaeuser and DuPont undertook ISR actions to clean up soil and/or debris at the Site, in accordance with the Model Toxics Control Act (MTCA) and the Consent Decree.

1.4 REMEDIAL INVESTIGATION REPORT OBJECTIVES

The purpose of the RI was to collect, develop, and report sufficient information regarding the Site to enable the completion of the RA and FS. The RI characterizes the nature and extent of contamination in the context of past activities at the Site. The RI report presents the analytical data for the media that have been collected at the Site. The data are presented for each RI area (Figure 1-2), as defined on the basis of historical manufacturing and production operations at the Site.

This RI summarizes the results of soil, groundwater, surface water, and sediment investigations conducted within the CDB. These investigations were conducted in accordance with the RI Management Plan (Hart Crowser 1992a). The Management Plan included an evaluation of locations outside of the CDB. The results of these investigations are or will be the topic of additional reports. In addition to the sampling specified in the RI Management Plan, soil verification data following ISRs and additional characterization data were collected in selected areas within the CDB.

The scope of the Site RI includes sample collection, laboratory analyses, data evaluation, and presentation of sampling results from four environmental media, as follows:

- 21,933 soil sample analyses (5,182 samples)
- 1,181 freshwater sediment sample analyses (20 samples)
- 12,038 groundwater sample analyses (283 samples)
- 1,528 surface water sample analyses (344 samples)

Because of the number and extent of interim actions conducted, many of the pre-RI and RI sampling points were removed during these activities and are no longer representative of current site conditions. Only those data representing current Site conditions within the CDB are included in this RI report. Samples excavated during ISR were removed from the RI database and were not used to characterize the Site.

The historical areas identified in the Consent Decree for further investigation and addressed in this document include the following:

- Area 1—Nitroglycerin Wash Water Gutter
- Area 2—Nitroglycerin Spill at No. 2 Nitrating and Separating House
- Area 3—Nitroglycerin Spill Along Gutter Line
- Area 4—Lead Residual at No. 2 Nitrating and Separating House
- Area 5—DNT Waste Drum Area
- Area 6—Crystallizer Drum Area
- Area 7—Waste Drainage Pit (Old Salt Lake)
- Area 10—Aluminum Water Gel Area
- Area 11—Water Gel Wash-Up Waste Pit Area
- Area 12—Works Magazine Landfill
- Area 16—Kettle Beneath Area 5
- Area 18—Nitroglycerin Production and Powderline Area
- Area 24—Upper Powerhouse
- Area 25—Acid Production Area
- Area 26—Waste Acid Recovery Area and Kettle
- Area 31—Burning Ground

- Area 38—Box Production Area and Drywell

The Consent Decree also identified Area 40, the Black Powder Area; however, as discussed previously, this area (also known as Parcel 2) has already been cleaned up and is no longer part of the Consent Decree process. For the purposes of the RI, Areas 1 through 4 and Area 18 have been combined into Area 18/1/2/3/4 to facilitate soil quality characterization.

The following seven areas were also identified as areas within the CDB for further investigation, based on additional historical information review.

- AP-A—Powder Test Ground
- AP-B—Smokeless Powder Dump (Phase II—Site 22)
- AP-C—Smokeless Powder Nitrating/Grinding House
- AP-D—Asphalt Paint Building
- AP-E—Main Transformer House
- AP-F—Nitrocotton Area (Drying House and Bunkers)
- AP-G—Decontamination Areas (Phase II—Site 23)

Three additional areas (Site Reference Area, LR-68, and narrow-gauge railroad [NGRR]) were identified for further study during the RI field activities. In addition to the areas identified above for RI evaluation, historical Site areas and miscellaneous Sitewide hot spot areas (Areas 1, 2, 3, 4, 5, 6, 8, 10, 18, 19, 20, 25, 26, 30, 31, 35, 36, 38, 39, and others), were approved by Ecology for ISR. Areas 15 and 32 have had early independent cleanup actions completed. ISR activities are discussed in Section 2.20. Table 1-1 summarizes the above information.

Specific objectives associated with the RI characterization phase of the project included the following:

- Determination of the lateral and vertical distribution of soil contamination within the RI areas
- Evaluation of the distribution and concentrations of constituents in Site groundwater, surface water, and freshwater sediments
- Refinement of the Site hydrogeologic conceptual model of the multi-aquifer groundwater system
- Determination of aquifer properties and groundwater flow rates
- Determination of representative area background concentrations for the Site soil and groundwater

1.5 FIELD INVESTIGATIONS

Pre-RI field investigations are summarized in the Phase I and Phase II Site Characterization Reports (Hart Crowser 1986 and 1987, respectively). The studies summarized in this report were conducted for Weyerhaeuser and DuPont between 1987 and September 2001. Studies performed after 1992 were conducted in accordance with the RI/FS Management Plan (Hart Crowser 1992a). Studies completed prior to 1992 were done using standard professional practices. The

Management Plan was prepared in consultation with Ecology, the public, and other participating agencies, in accordance with the following process:

- The Draft Management Plan (Hart Crowser 1992a) was reviewed by Ecology and revised in accordance with Ecology's comments between August 1991 and January 1992.
- The Draft Management Plan was available for public review between December 1991 and January 1992.

Field investigations conducted to meet the specific objectives stated above include:

- Surficial and deep soil sampling and analysis in 24 production-related areas
- Systematic sampling of soils outside of the production-related areas
- Water level measurements and surface water and freshwater sediment sampling and analysis in two surface water bodies—Sequalitchew Creek and Old Fort Lake
- Water level measurements, aquifer testing, and groundwater sampling and analysis for the Water Table and Sea Level Aquifers, including sampling and analysis of discharge at springs
- Area background soil and groundwater sampling and analysis

1.6 REPORT ORGANIZATION

Subsequent sections of this RI report are organized by medium—soil quality characterization by area (Section 2), groundwater characterization (Section 3), and surface water and freshwater sediment characterization (Section 4). Section 5 consists of a list of references cited in the report. Following the text are supporting tables and figures. All figures and tables were developed on the basis of information provided to URS in an analytical database submitted in final form for this RI on April 1, 2002 (Pioneer 2002). Appendices contain a discussion of field procedures and field exploration logs (Appendix A); soil quality data tables (Appendix B); and groundwater, surface water, and freshwater sediment quality data tables (Appendix C). Appendix D includes grain size distribution data for soil samples collected during the RI. Appendix E includes the data quality assessments for all data.

This section presents the findings of the RI soil characterization efforts at the Site. Information provided for each area in Sections 2.4 through 2.20 varies depending on the complexity of the area and the number and extent of detected constituents. Appendices A and B present field procedures and soil quality summary tables, respectively.

2.1 SITEWIDE SOIL CONDITIONS

Steilacoom Gravels constitute the surficial soils of the Site. The Steilacoom Gravels consist of brown and gray stratified sands and gravels, with cobbles and occasional zones of siltier sand. The Steilacoom Gravels were deposited during the retreat of the final (Vashon) glaciation in high-energy meltwater channels, which originated in a proglacial lake located in the present-day Puyallup River valley to the east (Walters and Kimmel 1968).

Over much of the eastern and central portions of the Site, the thickness of the Steilacoom Gravels typically ranges from 20 to 40 feet in these glacial meltwater channels. Along the western margin of the Site, the outwash channels feed into a large glacial delta (Sequalitchew Delta) within which the Steilacoom Gravels are more than 300 feet thick (extending below sea level). Cross-bedded gravel layers are commonly observed to dip toward Puget Sound within these deltaic deposits in the western portion of the Site.

Soil horizons developed on top of the Steilacoom Gravels consist of dark brown to dark gray, gravelly, sandy loam with variable percentages of organic matter and volcanic ash (Spanaway and Everett Series; Anderson et al. 1955). These soil horizons range in thickness from a few inches to approximately 3 feet depending on topography and vegetation. Soils developed on the geologic kettle floors include layers with higher silt and organic contents, indicating that the depressions may have been periodically flooded since the retreat of the Vashon glaciation, creating alternately dry and marshy conditions.

2.2 AREA BACKGROUND SOIL QUALITY

Twenty RI soil samples (BG-501 through BG-520) and three pre-RI soil samples (BG-SS-2, BG-SS-3, and BG-SS-5) were collected from outside of the CDB to define “Site area background” soil quality in accordance with MTCA. The majority of samples were obtained from locations to the south and east. Three samples were obtained from the coastal bluff to the north of the Site, as shown in Figure 2.2-1. The samples were positioned in locations that (1) have the same basic characteristic as Site soils, (2) have not been influenced by releases from the Site, and (3) have not been influenced by releases from other localized human activities, in accordance with WAC 173-340-709(2). Sampling locations were chosen to minimize the potential influence of airborne particulates settling on Site soils.

The Site area background soil samples were collected from undisturbed vegetated areas, with no apparent anthropogenic influences. The upper 6 inches of soil were composited after scraping away 1 to 4 inches of forest duff from the surface. Soils were generally described as moist, brown to black, silty, gravelly sand and are typical of the soils developed on top of the Steilacoom Gravels. Site area background soil samples were analyzed for the full list of parameters analyzed in on-Site soil samples, including 14 metals, polycyclic aromatic hydrocarbons (PAHs), nitrates, nitroaromatic explosives (NAX), nitroglycerine (NG), monomethylamine nitrate (MMAN), total petroleum hydrocarbons (TPH), semivolatile organic

compounds (SVOCs), volatile organic compounds (VOCs), polychlorinated biphenyls (PCBs), and organochlorine (OC) and organophosphorus (OP) pesticides. Ten additional samples (BG-511 through BG-520) were collected from similar locations outside the CDB and analyzed only for arsenic (Figure 2.2-1).

2.2.1 Summary of Results

A summary of Site area background soil quality is presented in Table 2.2-1. Metals, which are common and natural components of soil minerals, were the primary constituents detected. Nitrates, which are also naturally occurring, ranged from 0.8 to 4.2 mg/kg and averaging 2 mg/kg.

Organic Constituents

Low concentrations of three PAHs (acenaphthene, benzo(a)pyrene, and chrysene) were detected in at least one sample. PAH compounds are found in natural environments as a result of wood decay, forest fire, or other natural causes (Howard 1990). The presence of PAHs in area background samples does not diminish the samples' suitability or representativeness. In studies of background soil quality in rural areas (Harper-Owes 1985; Boyce and Michelsen 1993), PAH compounds were reported in a majority of soil samples at concentrations comparable to those reported in the Site area background samples (i.e., hundredths to tenths of one part per million).

Bis(2-ethylhexyl)phthalate, a common laboratory contaminant, was detected in three samples at concentrations close to or below the detection limit. No other VOCs or SVOCs were detected above their respective detection limits. No TPH, NAX, NG, MMAN, PCBs, or pesticides were detected in the Site area background samples. Based on the absence of organic anthropogenic constituents in the soil analyses, this set of samples is appropriate for defining area background quality in the vicinity of the Site.

Metals

Of the 14 metals tested (priority pollutant metals plus aluminum), thallium was not detected in any of the background samples; selenium was detected in only 1 sample; and mercury was detected in 3 of the 10 samples. The other metals were detected in all or a majority of the samples. Three background samples collected during the pre-RI produced comparable values for five of these metals (aluminum, antimony, chromium, lead, and zinc), and these three samples are included in the evaluation of background soils.

2.2.2 Comparison With Regional Background Soils

Metals concentrations for the Site area background soils were compared with regional background concentrations from Puget Sound (Ecology 1994). This Ecology background study did not address four metals (antimony, selenium, silver, and thallium). For these metals, other available references were used (Harper-Owes 1985; METRO 1985; Shacklette and Boerngen 1984). The 90th percentile concentrations of metals in the Site area background soils were calculated for comparison purposes. It should be noted that for several metals, only 11 of 14 samples were available; however, the data distributions were lognormal except for selenium and thallium, which had mostly censored data. The 90th percentile Site area and Puget Sound regional background concentrations are compared in Table 2.2-2.

The majority of metals exhibit comparable 90th percentile concentrations between the Site area background samples and Puget Sound regional background samples. The Site area background 90th percentile concentrations for five metals (antimony, arsenic, cadmium, lead, and mercury) are above the regional 90th percentiles. The 90th percentile arsenic concentration in Site area background samples (33 mg/kg) is above the 90th percentile arsenic concentration of 7.3 mg/kg reported for the Puget Sound (Ecology 1994). Ecology has accepted this value for arsenic as being representative of area background even though it is above MTCA Method A and B levels. The 90th percentile lead concentrations in Site area background samples (52 mg/kg) is above the 90th percentile lead concentration of 24 mg/kg reported for the Puget Sound (Ecology 1994).

The 90th percentile concentrations for antimony and mercury for the Site area background samples are also above the 90th percentile regional values. The Site area background 90th percentile concentration for cadmium is marginally above the Puget Sound regional value.

The 90th percentile concentrations for aluminum, beryllium, chromium, copper, nickel, selenium, silver, zinc, and thallium for the Site area background samples are equal to or less than the 90th percentile Puget Sound regional background concentrations.

2.3 INTRODUCTION TO AREA-SPECIFIC SOIL QUALITY

Sections 2.4 through 2.19 present the soil quality information collected for each of the RI areas and areas of potential concern (APs). Each area-specific section includes the history of activities, subsurface conditions encountered, and constituents detected in soils. It should be noted that just because a constituent is detected in soil does not mean that it is above levels of potential concern. Section 2.20 presents a summary of the results from ISR actions. The purpose of this section is to present current Site data. Sample analytical results were not compared to regulatory criteria in this RI. The current analytical data set for soil quality analyses for each area (pre-RI, RI, additional characterization samples, and ISR verification samples), including detection limits, is presented in Appendix B.

Validated analytical results from the RI project laboratories were used. Duplicate analyses were excluded. During Site work, nearly 1,000 field screening analyses were collected for dinitrotoluene (DNT) (Modified EPA Method 8090), TPH, arsenic and lead (x-ray diffraction [XRF]). Good correlations were established between the screening results and laboratory confirmation results for each constituent except arsenic (XRF interference). In all cases, the screening data were used only for field characterization and ISR work and were not retained in the database developed for this RI (Pioneer 2002).

Pre-RI characterization data were included if these data were of sufficient quality. Pre-RI data that were excluded from the Site database are the following:

- Oil and grease data (EPA Method 413.2) due to the nonspecificity of the analytical methods (i.e., this method measures natural oils and greases in addition to petroleum constituents)
- Selected PCB and PAH data due to insufficient detection limits
- Samples composited from greater than 5-foot vertical intervals
- Samples that could not be accurately relocated in the field based on field evidence (e.g., staking, flagging, or pre-RI exploration plans [pre-RI locations were not surveyed])

Although selected area soil samples were analyzed for potential metals leachability using the toxicity characteristics leaching procedure (TCLP), all of these sampling locations were excavated during the 2000 ISR, with the exception of one sample in Area 26 (addressed in the RA and FS). Therefore the TCLP analyses are not representative of current site conditions and are not discussed further in this RI.

One or more figures, showing sampling locations, are included for each area. Figure 2.3-1 is the legend for all the area-specific figures. In areas where ISR excavation or grading has occurred, depths for all samples (both pre- and postexcavation) within excavations less than 2 feet deep are referenced to the existing excavation grade. Depths for all samples (both pre- and postexcavation) within excavations greater than 2 feet deep are referenced to original (preexcavation) grade. Exceptions to this reporting convention are for Area 5, the Area 31 ravine, and all interim corrective actions that occurred after 1999. Depths for samples within these two areas are referenced to existing excavation grade. The depth assumptions used for data presentation in this report may not represent actual future elevations. References to samples collected at specific depths in boreholes are cited by the area in which they were collected, the type of collection method, and the sampling depth. For example, sample 7-B-503 represents "Area 7, borehole 5, sampled at 3 feet."

Borehole sampling locations are shown in a figure as 7-B-5 without an indication of the sampling depth. The individual samples and depths from each borehole are included in the soil quality tables provided in Appendix B.

Because of the number and extent of interim actions conducted, many of the pre-RI and RI sampling points were removed during these activities and are no longer representative of current Site conditions. Therefore, these data are not presented in the RI. All figures and tables were developed on the basis of information provided to URS in an analytical database submitted in final form for this RI on April 1, 2002 (Pioneer 2002).

2.4 AREA 6—CRYSTALLIZER DRUM AREA SOIL QUALITY

2.4.1 History of Activities

According to former DuPont employees, Area 6 was used for disposal of defective 55-gallon ammonium nitrate drums used at the ammonium nitrate plant.

2.4.2 Soil Conditions

During the excavation of a test pit in the center of the former ammonium nitrate plant foundation, a concrete slab was encountered approximately 3 feet below grade. Subsequently, test pit 6-TP-501 was relocated along the western edge of the foundation, where excavation to a depth of 10 feet was possible. At this location, fill containing demolition debris (e.g., bricks and mortar) was encountered to a depth of 5 feet. A 4-foot vertical length of 3-foot-diameter steel casing filled with soil was observed between depths of 1 and 5 feet. Along the northern wall of the excavation, the concrete foundation was observed to extend to a depth of 6 feet below grade. Below the concrete foundation, Steilacoom Gravels were encountered to a depth of 10 feet. Soils in 6-TP-501 were later excavated to a depth of 10 feet during ISR. Steilacoom Gravels

were also observed to a depth of 10 feet in 6-TP-502, located north of the foundation (Figure 2.4-1).

2.4.3 Constituents in Soil

Laboratory analyses performed on soil samples from Area 6 included eight total metals, TPH, and nitrate. Each of these analytes was detected in at least one sample from Area 6.

The RI soil quality data and associated sampling depths for Area 6 are summarized in Table B-1.1. Sampling locations are shown in Figure 2.4-1.

TPH concentrations in Area 6 range from 23 to 1,900 mg/kg. Results from the paraffin investigation (Hart Crowser 1996) indicated that the TPH in Area 6 was heavy oil-range petroleum, not paraffin.

ISR for this area is described in Sections 2.20.1 and 2.20.16.

2.5 AREA 7—WASTE DRAINAGE PIT (OLD SALT LAKE) SOIL QUALITY

2.5.1 History of Activities

This natural geologic kettle formation, defined as Area 7 and historically referred to as Old Salt Lake, received liquid and slurry wastes from the main powerhouse tank moats; oil residues from boilers, boiler blow down, and sewer drainage; and waste salts from the former nitric acid plant since the early 1900s. Waste materials were discharged via a subsurface pipeline to a swale leading into the south side of the kettle. Aerial photographs (1942 and 1961) indicate that liquid levels appear to have been near the upper limit of the kettle perimeter at various times in the past.

2.5.2 Soil Conditions

The general subsurface materials encountered within the Area 7 kettle consist of a fine-grained, non-native fill material overlying Steilacoom Gravels. The fill material consists of very light to dark gray silt- and clay-sized material mixed with variable percentages of sand, gravel, and wood fragments. The fine-grained material was observed to be finely laminated in some locations and interbedded with buried soil horizons (roots) in other locations, indicative of episodic fill deposition.

The fill material was observed to cover most of the kettle floor and much of the swale leading into the kettle from the south. The fill was not observed on the kettle walls or outside of the kettle. The fill thickness increased toward the kettle center, as was clearly observed in an observational test pit, 7-TP-501, excavated from the southern kettle wall toward the kettle center (Figure 2.5-1). Within the kettle bottom, the fill thickness was variable, typically extending to depths of 5 to 13 feet below grade, with a maximum observed thickness of 18 feet in 7-B-503.

Beneath the fill, Steilacoom Gravels were encountered to the depth of exploration below the kettle floor (75 feet in 7-B-503). Monitoring well MW-1, located immediately north of the Area 7 kettle (Figure 2.5-1), penetrated 220 feet of Steilacoom Gravels. The water table in the unconfined portion of the Sea Level Aquifer (Steilacoom Gravels) is at a depth of approximately 180 feet below grade at MW-1 (approximately 165 feet below the kettle bottom).

A thin discontinuous layer of weathered Bunker C residue (hardened tar-like material) occurred over more than half of the surface at the bottom of the kettle and over the lower portions of the kettle walls. The residue was not encountered more than approximately 4 to 6 inches below grade in any pre-RI or RI explorations. In addition, a viscous Bunker C oil staining occurred at the surface in the swale and in the southwestern portion of the kettle.

Green and yellow staining of the gravels was observed in all subsurface explorations within the kettle, except test pits 7-TP-502 and 7-TP-504, which were located along the lower kettle walls. A faint sulfur-like odor was also detected in subsurface samples (to 15 feet) of the fill material from the three RI borings within the kettle. This odor was generally not discernible in the open test pit excavations. Gravels at the surface in the kettle were typically bleached, pitted, and crumbly, indicating deterioration related to historical discharge of wastes from the acid production area. Gravels in the subsurface also showed signs of deterioration, although not to the same degree as the surficial fill materials.

2.5.3 Perched Water Occurrence

During drilling of RI boring 7-B-503 in July 1992, vertically discontinuous zones of perched water were encountered between depths of approximately 20 and 33 feet in Steilacoom Gravels underlying the fill material. However, in this boring and in others, no low-permeability soil units (e.g., silts), which would constitute a significant perching unit for groundwater, were observed within the Steilacoom Gravels.

In accordance with the Sampling and Analysis Plan (Hart Crowser 1992a), a monitoring well was installed within the zone of apparent perched saturation encountered in boring 7-B-503. During attempted well development the day after installation, the well bailed dry after one casing volume was removed, suggesting that the zones of saturation are discontinuous. Due to the lack of water level recovery, no significant well development could be achieved in the perched-zone well. Groundwater from the perched-zone monitoring well 7-B-503 was sampled after the well was bailed dry. The water bailed from the well was observed to be exceptionally turbid. Sufficient water was collected for analyses of total and dissolved metals, NAX, and PAHs. These data are discussed in Section 3.2. Monitoring well 7-B-503 was dry during the August 1992 round of water level measurements and in all subsequent rounds of water level measurements and groundwater sampling.

Saturated conditions were not encountered to a depth of approximately 29 feet during drilling of the RI borings 7-B-501 and 7-B-502 in February 1992. Zones of saturation were encountered in some of the pre-RI borings drilled to similar depths in December 1986 and April 1987. A piezometer installed in pre-RI boring 7-B-4 was dry within 1 week after its installation, indicating that the saturation is transient.

The observations from drilling in this kettle, and in the kettles in Areas 16 and 26 (discussed in Sections 2.9 and 2.12, respectively), indicate that zones of saturation beneath the kettles are transient and discontinuous (both laterally and vertically). The water observed during drilling may represent infiltrating wetting fronts rather than zones of true saturation. This would also be consistent with the lack of observed lower permeability layers (e.g., silts), which would act to perch infiltrating water.

2.5.4 Constituents in Soil

Laboratory analyses performed on soil samples from Area 7 included up to nine total metals, TPH (Bunker C), explosives, SVOCs, PAHs, pesticides, and PCBs. All of these analytes were detected in at least one sample from Area 7, except for explosives, which were not detected in any samples from this area.

The RI soil quality data and associated sampling depths for Area 7 are summarized in Tables B.2-1 through B.2-6 in Appendix B. Sampling locations are shown in Figure 2.5-1.

2.6 ISR FOR THIS AREA IS DESCRIBED IN SECTION 2.20.15. AREA 10—ALUMINUM WATER GEL AREA SOIL QUALITY

2.6.1 History of Activities

Interviews with former DuPont employees indicate that residual aluminum water gel (consisting of salts, nitrates, aluminum, and gelling agents) was reportedly buried in an area approximately 10 feet by 12 feet in Area 10. During pre-RI field work, two test pits were excavated and two soil samples were collected for analyses.

2.6.2 Soil Conditions

During the RI, three test pits (10-TP-501, 10-TP-502, and 10-TP-503) were excavated to a depth of 10 feet to confirm pre-RI results and assess the vertical extent of constituents. During the excavation of one test pit, approximately 1 dozen deteriorated water gel bags were observed in the top 2 feet. Some of the bags contained residual water gel. Scattered yellow spheroidal pellets (flake trinitrotoluene [TNT], according to a former DuPont employee) were observed in the sand. Two soil samples were analyzed for nitrate and aluminum; one sample was analyzed for TNT only; and one sample was analyzed for NG, DNT, and TNT.

2.6.3 Constituents in Soil

Laboratory analyses performed on soil samples from Area 10 included up to 14 total metals, explosives, SVOCs, and PAHs. Total metals, SVOCs, and explosives were detected in at least one sample from Area 10. The compound bis(2-ethylhexyl)phthalate, the only SVOC detected, was found in a single sample at a concentration near the detection limit and was therefore qualified. PAHs were not detected in any samples from Area 10. Elevated TNT (270 and 840 mg/kg) and DNT (3 mg/kg) concentrations were found. These locations were remediated during the 1999, 2000, and 2001 ISR efforts (see Section 2.20). SVOCs, NG, and lead were not detected in these pre-RI samples. Nitrate concentrations (3.0 and 3.4 mg/kg) were within the range of background concentrations.

The soil quality data, associated depths, and analytes for Area 10 are summarized in Tables B.3-1 through B.3-3 in Appendix B. Sampling locations are shown in Figure 2.6-1.

ISR work conducted in Area 10 is described in Sections 2.20.14 and 2.20.16.

2.7 AREA 11—WATER GEL WASH-UP WASTE PIT AREA SOIL QUALITY

2.7.1 History of Activities

Area 11 was used for disposal of water gel wash-up material and associated packaging materials. The disposal area, a shallow depression approximately 50 by 50 feet, was reportedly detonated as part of plant decommissioning prior to Weyerhaeuser's acquisition of the property. During pre-RI sampling, six plastic mesh bags about 2 feet long by 10 inches wide and containing a grayish powder were found on the surface. Fill materials encountered during excavation of six pre-RI test pits included a fine-grained material (possibly sawdust) with interbedded leaves and sticks.

Pre-RI sampling data from test pit 11-TP-6 indicated slightly elevated TNT concentrations. Concentrations of lead, nitrate, NG, and MMAN were not elevated.

2.7.2 Soil Conditions

One 28-foot boring (11-B-501) and four 10-foot test pits (11-TP-501 through 11-TP-504) were completed for the RI within and around the former disposal area to define the lateral and vertical extent of TNT and DNT and to assess the potential presence of other constituents. The boring was advanced at the approximate center of the shallow depression. Fill material observed during pre-RI sampling was not encountered during advancement of this boring or during excavation of the RI test pits. Steilacoom Gravels were encountered to the depth of exploration in all RI explorations. At 17 feet below ground surface, an approximately 1-foot zone of water was observed perched on a 2-foot layer of till-like material observed at a depth of 18 to 20 feet. This zone appears to be similar to the zone of groundwater observed perched on till during the drilling of monitoring wells MW-22/MW-27 to the north (refer to Section 3.1).

2.7.3 Constituents in Soil

Laboratory analyses performed on soil samples from Area 11 included up to 14 total metals, TPH, explosives, SVOCs, and PAHs. Total metals, TPH, and explosives were detected in at least one sample from Area 11. SVOCs and PAHs were not detected in any samples from this area.

The RI soil quality data, associated depths, and analytes for Area 11 are summarized in Tables B.4-1 through B.4-4 in Appendix B. Area 11 sampling locations are shown in Figure 2.7-1.

2.8 AREA 12—WORKS MAGAZINE LANDFILL SOIL QUALITY

2.8.1 History of Activities

Materials related to explosives packaging activities in the Works Magazine were reportedly buried in shallow excavations in several areas of the Works Magazine Landfill. Materials identified or reportedly buried (by former DuPont employees) include explosives packaging, auto shop wastes, empty ammonium nitrate drums, and residual water gel. Seven units of the landfill, designated 12-1 through 12-7, were identified in the pre-RI work. As discussed below,

Unit 12-4 was deleted from further evaluation because only native materials were observed in subsurface explorations.

A total of 29 pre-RI test pits were excavated to determine the presence or absence of buried materials and to provide soil samples from the units.

During pre-RI sampling in Area 12, elevated MMAN concentrations were found at one location each in Unit 12-1 (2,900 mg/kg), Unit 12-2 (1,000 mg/kg), and Unit 12-6 (30,000 mg/kg). Concentrations of other constituents in the pre-RI samples were not elevated.

2.8.2 Soil Conditions

During the RI, 5 soil borings and 24 test pits were completed within and around the former disposal units to define the lateral and vertical extent of MMAN and to assess the potential presence of other constituents in this area. Boring and test pit locations and approximate debris boundaries are shown in Figure 2.8-1. Debris fill was encountered at several explorations within the landfill units. Steilacoom Gravels were encountered in all explorations outside of the fill areas. Native soils from a gravel borrow pit located north of Unit 12-2 were used to cover debris in Units 12-1, 12-2, 12-3, 12-5, and 12-6.

Unit 12-1

Debris, including empty water gel bags and plastic and metal strapping, was observed in 6 of 10 test pits and in the one boring in this unit. Generally, debris extended from depths of approximately 2 to 6 feet and was covered on the surface by 1 to 2 feet of dark brown, gravelly sand. The fill materials area measured approximately 150 by 20 feet.

Unit 12-2

Debris was observed in all 18 test pits and in both borings in this unit. Generally, debris extended from depths of approximately 2 to 8 feet and was covered on the surface by 1 to 2 feet of dark brown, gravelly sand. Debris consisted of water gel bags, some with residual water gel, wooden posts, paraffin-coated cardboard boxes, railroad ties, asbestos-containing material, and other mixed solid waste (e.g., old truck tires, tin cans, plastic, foam rubber, and metal banding). All asbestos-containing material (ACM) was removed and disposed of at an approved landfill during the RI excavation by TLH Abatement Inc. Unit 12-2 is the largest of the units, and the fill materials area measured approximately 550 by 150 feet. Unit 12-2 is bounded on the north by a gravel borrow pit from which native soils were historically obtained for covering the landfill units.

Unit 12-3

Debris was observed in all six test pits excavated in this unit. Generally, debris extended from depths of approximately 2 to 6 feet and was covered on the surface by 1 to 2 feet of dark brown, gravelly sand. Debris included water gel bags with residual water gel, and plastic tubing. The fill materials area measured approximately 210 by 50 feet.

Unit 12-4

Unit 12-4 is a 10- by 200-foot depression that apparently was never filled. The depression may be a gravel borrow pit similar to the one north of Unit 12-2. Three test pits were excavated in this unit (Figure 2.8-1). No debris was observed during excavation of the pre-RI or RI explorations, or during an RI field reconnaissance. Therefore, Unit 12-4 was not evaluated further.

Unit 12-5

Debris was observed in all six test pits excavated in this unit. Generally, debris extended from depths of approximately 2 to 6 feet and was covered on the surface by 1 to 2 feet of dark brown, gravelly sand. Debris included packaging materials (pressed cardboard and plastic strapping). The fill materials area measured approximately 125 by 75 feet.

Unit 12-6

Debris was observed in three of five test pits, but not in the one soil boring in this unit. Generally, debris extended from depths of approximately 2 to 7 feet and was covered on the surface by 1 to 2 feet of dark brown, gravelly sand. Observed debris included white plastic tubing containing residual water gel, and other mixed solid waste (e.g., tin cans, ceramics, and glass jars). Based on test pit excavations, this unit appears connected to Unit 12-7.

Unit 12-7

Debris was observed in two of three test pits, but not in the one soil boring in this unit. Debris included white plastic tubing containing residual water gel, and cardboard. Based on test pit excavations of Units 12-6 and 12-7, the two units appear to be connected (as shown in Figure 2.8-1). Dimensions of the fill materials for this combined unit area are approximately 200 by 20 feet.

Inter-Unit Test Pits

Debris was observed in two of five test pits excavated between delineated landfill areas. Debris included empty water gel bags and mixed solid waste (e.g., logs, styrofoam, cardboard, and plastic banding). Both test pits containing debris (12-TP-501 and 12-TP-505) are located within redefined unit boundaries (Units 12-2 and 12-5, respectively) (Figure 2.8-1). All other inter-unit test pits contained only native material and thus do not appear to be associated with any landfill unit.

2.8.3 Constituents in Soil

Laboratory analyses performed on soil samples from Area 12 included up to 14 total metals, TPH, explosives, SVOCs, PAHs, pesticides, and PCBs. The TPH (Method 418.1) results were associated with paraffin-coated cardboard except in one location where automobile parts were observed (test pit 12-2-TP-9). Paraffin wax is generally regarded as biologically inert. Additionally, no carcinogenic PAHs (cPAHs) were detected in 22 samples analyzed from this area. All of these analytes were detected in at least one sample from Area 12, except for pesticides and PCBs, which were not detected in any samples from this area.

Tables B.5-1 through B.5-6 in Appendix B detail the RI soil quality data, associated depths, and analytes in Area 12. Figure 2.8-1 shows the sampling locations.

2.9 AREA 16—KETTLE BENEATH AREA 5 SOIL QUALITY

2.9.1 History of Activities

Area 16 encompasses the large natural geologic kettle beneath Area 5, referred to as the DNT Waste Drum Area. Former DuPont employees reported that the kettle received cooling waters and liquid wastes from the acid production area (Area 25) to the west and southwest. Historical aerial photographs indicate the kettle periodically contained water during plant operation. The liquids were discharged to the Area 16 kettle through a pair of pipes that daylighted near the top of the kettle walls. Erosional gullies formed beneath the pipe outfalls and extended down the kettle walls to the kettle floor. These gullies and surrounding soils were removed during the Area 5 ISR documented by Hart Crowser (1994c).

During pre-RI sampling in Area 16, elevated lead concentrations were found. To facilitate staging of the Area 5 ISR, the upper foot of soil was graded in the Area 16 kettle bottom following the first phase of RI soil sampling. The approximate limit of the graded area, which transitions into the Area 5 ISR excavation area on the west, is shown in Figure 2.9-1. RI soil borings 16-B-501 and 16-B-505 and surface samples 16-SS-504 through 16-SS-523 were completed after the grading. All depths in Tables B.6-1 through B.6-7 in Appendix B and in Figure 2.9-1 are referenced to the current grade.

2.9.2 Soil Conditions

The generalized sequence of soils encountered in the Area 16 kettle consisted of scattered fill materials overlying varying thicknesses of soil developed on Steilacoom Gravels. Most fill materials from the base of the Area 5 hillside were removed during the Area 5 ISR. Bunker C residue was observed as a thin discontinuous surficial layer over portions of the ungraded kettle bottom.

A veneer of finer-grained soils typically less than 4 feet thick occurred over much of the kettle bottom. Because finer-grained materials are continually being eroded and transported from the kettle walls down slope, the thickest accumulation of fine-grained soils was found in the kettle bottom rather than on the kettle walls.

Beneath the surficial soil veneer, the Steilacoom Gravels were encountered to the exploration depth of 75 feet in boring 16-B-501. On-site monitoring wells indicated that the sequence continues uninterrupted to below msl (to depths of over 200 feet outside of the kettle). Regional information indicates that the Steilacoom Gravels extend to more than 100 feet below msl, nearly 250 feet below the kettle bottom.

Data from the four monitoring wells surrounding the kettle (MW-2, MW-3, MW-4, and MW-5; see Figure 3.1-1) and the deep soil boring within the kettle bottom (16-B-501) indicate that the Area 16 kettle is located west of the “Cutoff” (formerly known as the Kitsap Cutoff), which is the western extent of the Aquitard (formerly known as the Kitsap Aquitard) and Water Table Aquifer, as discussed in Section 3.1. Although Area 16 is located west of the “Cutoff”, the water table surface continues to slope relatively steeply beneath the kettle. A 30- to 40-foot drop in

water table elevation was observed from the east side (MW-4 and MW-5) to the west (MW-2 and MW-3) side of the kettle. Based on the elevation of the kettle bottom (140 to 145 feet), the water table lies 100 to 120 below the floor of the kettle basin.

Thin zones of saturation appear to exist in the shallow soils beneath the Area 16 kettle, but the saturation is transient and discontinuous (both laterally and vertically). Zones of silty sand were encountered within the stratified sands and gravels, but they are also laterally and vertically discontinuous. No continuous perching units (e.g., competent silts) were observed within the 75-foot-deep exploration beneath Area 16.

Wet soil samples were described in several intervals of the pre-RI and RI borings within Area 16. A piezometer screened between depths of 28 and 32 feet in pre-RI boring 16-B-4 contained water for a few weeks following its installation in spring 1987, suggesting a perched zone of saturation. However, the piezometer was dry during drilling of the RI soil borings in February 1992, following a period of relatively heavy rainfall. The tip of the water level sounder was wet following the measurements, suggesting the piezometer end cap had water in it at times. The piezometer was also dry during RI drilling in July 1992.

During drilling of the RI borings in February 1992, a few inches of water were observed in one of the three borings (16-B-504) between depths of approximately 9 and 14 feet. In borings 16-B-502 and 16-B-503, and at other depths in 16-B-504, samples were described in the field as wet, yet no standing water was measured in the borehole. This condition was also observed during drilling in the other two kettles (Area 7 and Area 26). In these cases, the wet samples may represent infiltrating wetting fronts rather than perched zones of saturation.

Boring 16-B-501, drilled in July 1992, was completed as a monitoring well to sample perched water if present, in accordance with the Sampling and Analysis Plan (Hart Crowser 1992a). No standing water was observed in the boring during drilling. The bottom of the well screen was set on a thin interval of silty sand; however, no water was observed in this well at the time of installation or in any of the subsequent rounds of groundwater sampling or water level measurements.

These combined observations, along with those from the other on-site kettles (Sections 2.5 and 2.12), indicate that perched water is not present beneath the kettles.

2.9.3 Constituents in Soil

Laboratory analyses performed on soil samples from Area 16 included up to eight metals, TPH (Bunker C), explosives, SVOCs, PAHs, pesticides, and PCBs. All of these analytes, except for SVOCs, were detected in at least one sample from Area 16. Endrin, detected in one sample, was the only pesticide detected. In addition, PCB-1254, detected in one sample, was the only PCB compound detected. SVOCs were not detected in any samples from this area. Based on site characterization results, detectable lead, barium, and chromium remain in this area.

Tables B.6-1 through B.6-7 in Appendix B provide a summary of the RI results and associated depths for Area 16. Figure 2.9-1 shows the sampling locations.

2.10 AREA 18/1/2/3/4—NITROGLYCERIN PRODUCTION AND POWDERLINE AREA SOIL QUALITY

2.10.1 History of Activities

This large area was used for the production of NG and dynamite. Area 18/1/2/3/4 encompasses the NG production area (Area 18 North and Area 1/2/3/4) and five dynamite production and packaging lines (Area 18 South), two cartridge dynamite lines, two gelatin dynamite lines (one of which was converted to water gel production in the 1960s), and one smokeless powder production line.

Area 18 North and Area 1/2/3/4 NG production facilities included nitrators, separators, and neutralizers. Two separate process lines (Nitrator No. 1, Separator No. 1, and a combined Nitrator/Separator House No. 2) were constructed between 1907 and 1909, along with associated Neutralizer House No. 1 and No. 2. A third separate process line consisting of Nitrator/Separator House No. 3 and Neutralizer No. 3 was added in 1915. Nitrator No. 1 and Separator No. 1 were burned as part of decommissioning in 1925; an explosion eliminated Combined Nitrator/Separator House No. 2 in 1938. A new facility was built over the remains of the original. The remaining facilities were burned during Site decommissioning between 1976 and 1977.

Area 1/2/3/4 includes the following specific sites:

- Area 1—NG Wash Water Gutter
- Area 2—NG Spill at No. 2 Nitrating and Separating House
- Area 3—NG Spill Along Gutter Line
- Area 4—Lead Residual at No. 2 Nitrating and Separating House

This area was investigated because of the potential for residual NG, lead debris, and wastewaters associated with NG production. As part of the production process, residual NG was settled out of the wash water during both the separating and neutralizing phases and reintroduced to the manufacturing process. Wash water (following NG settling) was then sent to a wash water gutter system (Area 1) that ran north of the combined nitrating/separating houses. In later years, wash waters, particularly from the neutralizers, were sent to seepage ponds adjacent to the individual facilities.

In the mid-1950s, a spill of approximately 300 pounds of NG occurred near the south steps of the No. 2 Nitrating and Separating House (Area 2). According to former DuPont employees, this spill was treated with sodium sulfide and later detonated during plant decommissioning. In 1961, approximately 100 to 200 pounds of NG were spilled from the NG gutter system (Area 3), and this area was treated with sodium sulfide and later detonated. Area 4 encompasses the debris resulting from decommissioning of the No. 2 Nitrating and Separating House, which contained lead sheeting.

The Powderline Area (18 South) included facilities to mix dynamite ingredients, pack cartridges, and box finished products. Facilities including mixing houses (in the central portion of Area 18), cartridge houses, and packing houses, followed a process line organization. Three lines were initially developed south of the NG area: two for cartridge dynamite (talley mix) and one for gelatin dynamite. The gelatin line ran along the eastern edge of the area. A fourth line, also for

gelatin, was added to the west in 1915. By the 1950s, the fourth line and one of the talley mix lines had been eliminated. The eastern line served for DNT gelatin production and subsequently was converted to water gel production in the 1960s.

The nitrostarch/smokeless powderline was constructed west of the other powderline facilities in 1916. It included four storehouses, four drying houses, a screening house, and a nitrating house. The facilities were converted in 1923 to reprocess surplus cordite and smokeless powder that had been returned by the U.S. military. The powder was reground to manufacture blasting compounds for farm use (sodatol and pyrotol). The reprocessing was completed in 1927. The buildings were burned during decommissioning in 1931.

Materials reportedly handled or present at these facilities include waste acid (with trace amounts of NG), lead, NG, MMAN, DNT, TNT, and nitrostarches. Lead linings, washtubs, and pipes were commonly used in the foundations of production facilities to contain process liquids or spills and reduce accidental sparking.

During the pre-RI site characterization, 101 samples were collected for constituent testing from 69 test pits and 9 hand augers in Areas 1, 2, 3, 4, and 18. Additional test pits were excavated for characterization of subsurface conditions. Constituent analytical results indicated elevated lead concentrations. TNT, DNT, and NG concentrations were not elevated. Aside from common laboratory solvents, VOCs were generally not detected. Subsequent to the pre-RI site characterization, many of these sampling points were removed during ISR and are no longer representative of current site conditions.

2.10.2 Soil Conditions

A variety of fill layers and non-native materials were observed in test pits from this area. Fill soils are generally composed of slightly silty, sandy gravel and gravelly sand—essentially regraded, local Steilacoom Gravels. Many of the production facilities had been bunkered by sloping berms of fill soil built up against the foundation walls. In addition, a variety of non-native materials (e.g., timbers) are mixed into fill soils.

Lead

Lead debris was observed at the surface or uncovered in the subsurface at several localities (at test pits 4-TP-2, 4-TP-7, 18-TP-16, 18-TP-32, and 18-TP-37; surficial soil from 4-TP-2, 4-TP-7, and 18-TP-37 was removed during ISR). Intact, 1/8-inch-thick lead sheeting over concrete floor pads was also observed (test pits 4-TP-8, 18-TP-17, and 18-TP-18; surficial soil in all three of these locations was removed during ISR). Most of this elemental lead was observed in the nitrators and neutralizers and has since been removed during ISR of lead debris.

Washwater Gutters

A buried concrete gutter was observed in a series of test pits that were originally designated as Area 1 (1-TP-6 through 1-TP-11). The gutter and an associated lateral gutter system carried residual process wash waters from the separators and neutralizers. The gutters were wood-covered troughs, concrete structures approximately 1 foot-wide and lined with tar. They led to a filtering house before wash waters were discharged to the ground in the vicinity of a 5-foot-deep depression at the western end of the main gutter. Most of the wash water system was no longer used after the 1950s, and subsequent site activities buried the gutters beneath 1 to 5 feet of fill.

Potential Asbestos-Containing Materials (ACM)

Where lead-lined floors were observed in the old foundations, the lead sheeting was sometimes separated from the concrete pad by a thin layer of potential ACM (4-TP-8 and 18-TP-18). Elsewhere, potential ACM was associated with metal ductwork (18-TP-550 and 18-TP-553) and shingles (18-TP-2). Potential ACM fragments were also noted with demolition debris in a number of explorations (18-TP-1, 18-TP-9, 18-TP-23, 1234-TP-503, and 18-TP-534). The top foot of soil was later excavated from locations 18-TP-534 and 18-TP-23 during ISR. Materials suspected by the field personnel to be potential ACM were evaluated by the on-site asbestos abatement contractor, TLH Abatement Inc. Any materials confirmed to be ACM by TLH Abatement Inc. were handled and disposed of by TLH Abatement Inc. at an appropriate landfill.

DNT/TNT Residual

During the RI characterization work, residual DNT/TNT was identified near the DNT Heater and Melt Houses (south of Neutralizer Nos. 1 and 2), the Gelatin Mixing House No. 1, and the Dynamite Mixing House Nos. 1 and 2. As a result of these observations, a program to systematically locate and remove residual DNT/TNT was initiated in the central part of Area 18. Initially, a peripheral zone of surface soils surrounding the DNT Heater Houses and Mixing Houses was inspected for residual DNT/TNT by systematically scraping and exposing the upper few inches of soil cover with a bulldozer. Suspected residual DNT/TNT was field tested using a colorimetric indicator test. The scraping operations uncovered additional residual DNT/TNT locations, most within a 150-foot radius of these foundations.

2.10.3 Constituents in Soil

Laboratory analyses that were performed on soil samples from Area 1/2/3/4 included up to eight metals, explosives, VOCs, SVOCs, and PAHs. All of these analytes, except for SVOCs, were detected in at least one sample from Area 1/2/3/4. NG, detected in one sample, was the only explosives compound detected. SVOCs were not detected in any samples from this area.

Laboratory analyses that were performed on soil samples from Area 18 included up to eight metals, TPH, explosives, PAHs, and nitrate. All of these analytes were detected in at least one sample from Area 18. Many of these sampling points were removed during ISR and are no longer representative of current site conditions.

The RI and ISR verification data for Area 18 and Area 1/2/3/4 are summarized in Tables B.7-1 through B.7-6 in Appendix B. Figure 2.10-1 shows the sampling locations for Area 1/2/3/4, and Figures 2.10-2 through 2.10-6 show the sampling locations for Area 18.

ISR work conducted in Area 18 is described in Section 2.20.3, 2.20.13, 2.20.14, 2.20.15, and 2.20.16.

2.11 AREA 25—ACID PRODUCTION AREA SOIL QUALITY**2.11.1 History of Activities**

Area 25 encompasses the facilities used for production of sulfuric and nitric acids and for storage of the production process materials (e.g., sulfur). Changes occurred in the layout of the acid

production area over the period of operations (1900s to 1970s). Maps showing two sets of composite historical features for the area developed from historical DuPont plant maps and aerial photographs were included in the Sampling and Analysis Plan (Hart Crowser 1992a).

Elevated lead concentrations were observed in pre-RI samples collected from Area 25.

Surficial grading of much of the northern portion of Area 25 was conducted to prepare staging and stockpile laydown areas in support of Area 5 ISR activities. In addition, surficial grading of a stockpile laydown area was conducted in the southern portion of Area 25 during ISR at the Trivelene melt house. Limits of graded areas and the limit of the Trivelene melt house excavation are shown in Figure 2.11-1. All sampling depths listed in Tables B.8-1 and B.8-2 in Appendix B and in Figure 2.11-1 are referenced to existing grade.

2.11.2 Soil Conditions

Steilacoom Gravels were observed to a depth of 10 feet in all Area 25 test pits. A 1- to 2-foot-thick veneer of demolition debris containing bricks, crushed rock, and deteriorated gravels was observed in 7 of the 24 RI test pits excavated in Area 25.

Sampling was also conducted to delineate the extent of surficial demolition debris within and adjacent to Areas 25 and 26. The debris appears to be associated with the demolition of the former buildings in the acid production (Area 25) and acid recovery (Area 26C) areas during plant decommissioning. For the purposes of this sampling, the samples were labeled AP-H to differentiate them from samples collected within the Area 25 and Area 26 production areas. However, the field reconnaissance of the debris indicated that, although the debris was observed outside the current boundaries of Areas 25 and 26, it was not widespread enough to warrant consideration as a separate area. As a result, the lead data from the AP-H sampling locations have been integrated with the data from Areas 25 and 26, and the surficial debris were evaluated as part of Areas 25 and 26. Thus, AP-H is not discussed further in this RI.

A brick wall was observed between depths of 1.5 and 4 feet in the sidewall of 25-TP-505, excavated within the former converter house foundation used in manufacturing sulfuric acid. Lead debris and ceramic pipe were observed in the upper foot of fill at 25-TP-503, excavated within the former scrubber house. A 3.5- by 6-foot, 1.5-foot-thick concrete slab was removed from the wall of this test pit during excavation. The bottom of the slab was weathered and stained a dark yellow color, likely related to the sulfuric acid production process. A similar yellow staining was observed with deteriorated gravels to a depth of 10 feet in this test pit. At 25-TP-514, the end of a clay drain pipe was observed in the north wall of the excavation, and deteriorated gravels were encountered to a depth of 12 feet, with bleached gravels from 12 to 14 feet. Surficial soils in 25-TP-514 were later excavated during ISR. Deteriorated gravels were also observed between depths of 1 and 4 feet in 25-TP-516, below 1 foot of nonweathered soil that appears to be fill.

2.11.3 Constituents in Soil

Laboratory analyses performed on soil samples from Area 25 included up to eight total metals, explosives, VOCs, SVOCs, and PAHs. Total metals and explosives were detected in at least one sample from Area 25. Many of these samples were removed during ISR and are no longer

representative of current site conditions. VOCs, SVOCs, and PAHs were not detected in any samples from this area.

Tables B.8-1 and B.8-2 in Appendix B provide an overview of the RI soil quality data for Area 25. Figure 2.11-1 shows the sampling locations.

ISR work conducted in Area 25 is described in Section 2.20.14 and 2.20.16.

2.12 AREA 26—WASTE ACID RECOVERY AREA AND KETTLE SOIL QUALITY

2.12.1 History of Activities

This area includes the facilities used for recovery of spent acids returning from the NG production area. Initially, both sulfuric and nitric acids were recovered in separate facilities. Subsequent (post-1940) processing methods substantially reduced the number of facilities. The area also includes two geologic kettles (Units 26A and 26B) located south of the recovery facilities (Figure 2.12-1). According to former DuPont employees, the large kettle (Unit 26A) received liquid discharge from the acid recovery area, the plant laundry, and the truck wash and vehicle maintenance facility. Aerial photographs from 1976 show liquid within this kettle. Historical information including aerial photographs indicate that the Unit 26B kettle did not receive liquid wastes.

The former waste acid recovery buildings (Unit 26C) and the small kettle (Unit 26B) were included within Area 25 (Acid Production Area) for the pre-RI site characterization (Hart Crowser 1987). Since Units 26B and 26C include facilities for storage and reprocessing of waste acids, rather than production of acids, these waste acid recovery buildings and both kettles have been included in Area 26 for evaluation in the RI.

During pre-RI sampling in Area 26, elevated lead, cPAH, and DNT concentrations were found.

2.12.2 Soil Conditions

Unit 26A and Unit 26B Kettles

Native soils within the kettles consist of 1 to 10 feet of dark gray, silty, gravelly sand with occasional silt lenses and abundant organic matter (surficial sandy loam), overlying brown, stratified sands and gravels (Steilacoom Gravels), which extend beyond the depth of exploration (100 feet at boring 26-B-503 within Unit 26A). The upper silty sand is thicker at the northern end of the Unit 26A kettle—up to 9 to 10 feet thick at 26-B-5, 26-B-501, and 26-TP-502, compared with 2 to 3 feet thick along the southern edge of the kettle. Some silty to slightly silty zones were encountered in the Steilacoom Gravels, but they appear to be discontinuous between explorations.

The Water Table Aquifer and Aquitard were not encountered to an elevation of approximately 70 feet msl in 26-B-503. This boring was drilled to a total depth of 100 feet specifically to confirm the presence or absence of the aquifer and aquitard at this location. This observation confirms the findings from MW-6 and the current hydrogeologic interpretation that the “Cutoff” (discussed in Section 3.1) is located east of Area 26.

Similar to conditions encountered in the other kettles (Area 7 and Area 16) during drilling of the pre-RI and RI borings, wet soil samples were commonly recovered without the ability to detect water in the auger. These conditions likely indicate wetting fronts infiltrating downward and are consistent with conditions encountered in the other kettles (Sections 2.5 and 2.9).

A zone of saturation was encountered, and a piezometer was installed (screened between depths of 19.5 and 24.5 feet) in the pre-RI boring 26-B-2, which was drilled in April 1987. Water was measured in the piezometer 2 weeks after its installation (Hart Crowser 1987). The piezometer had no measurable water in it during drilling of the RI borings in February and July 1992.

No NG was detected in the three samples collected from 26-TP-508 (within the former NG waste acid storage location) or in the sample collected from pre-RI test pit 25-TP-6, located downslope of the former building. In the Unit 26B kettle, lead debris removal was conducted in the location of the former NG waste acid storage and freezing house (the limit of excavation is shown in Figure 2.12-1).

Unit 26C—Waste Acid Recovery Area

Demolition debris was also encountered in six test pits (26-TP-510 through 26-TP-515) excavated in and around the former waste acid recovery buildings located north of the Unit 26A kettle (Figure 2.12-1). The debris consisted predominantly of bricks and crushed rock, with smaller quantities of wood and ceramic and lead piping. A graded veneer of demolition debris less than 2 feet thick was observed at the surface over much of Unit 26C and east of the road bounding the unit on the east. Beneath the debris, the soils were essentially the same as those observed elsewhere in Area 26—2 to 3 feet of dark gray, silty, gravelly sand overlying Steilacoom Gravels to the depth of exploration. Several additional samples (AP-H samples) were collected within and outside the limit of this debris. The locations of AP-H samples in the vicinity of Area 26 are included in Figure 2.12-1.

Lengths of 4-inch-diameter ceramic pipe were observed at depths of 1 to 2 feet in test pits 26-TP-510 and 26-TP-513. The pipe appeared to be in place (undisturbed) in 26-TP-513, but not in 26-TP-510. In 26-TP-513, the pipe sloped to the south, toward the Unit 26A kettle. A 12-inch-diameter ceramic pipeline, which also appeared to be in place and sloped toward the south, was observed across the full length of 26-TP-511. The ceramic pipe in each of the three test pits was oriented approximately north-south. In addition to the ceramic pipes, an 8-foot length of 3-inch-diameter lead pipe that did not appear to be part of a pipeline was pulled out of the north wall of 26-TP-512, at a depth of 1 foot. There was no indication that this lead pipe was connected to any other piping.

Discharge locations for several pipes were observed along the northern rim of the Unit 26A kettle. At one location a few feet upslope of hand auger 26-HA-502 (Figure 2.12-1), outlets for four pipes were found—a rusted 2-inch-diameter steel pipe and three ceramic pipes (with 4-, 8-, and 12-inch diameters). This location was later excavated to a depth of 10 feet during ISR. From what was visible at the location of the outlets and in the test pits, all pipes appear to originate from the acid recovery area located to the north. In addition, a length of 6-inch pipe was observed lying on the slope below the former Ammonia Neutralizing House, but the pipe did not appear to be in place. The pipe was near the top of an erosion gully that extends into the Unit 26A kettle (test pit 26-TP-502 was excavated within this gully; see Figure 2.12-1).

Stained soils were commonly observed at the surface and at depth in the Unit 26C test pits. Crumbly, deteriorated gravels and rock fragments (fill), commonly bleached or stained, were observed on the surface of much of the area including immediately downslope of the pipe outfalls (26-HA-502). Beneath the surface, rusty yellow soil staining was observed in the three test pits where ceramic piping was observed (26-TP-510, 26-TP-511, and 26-TP-513). In 26-TP-510, the staining was minor and did not appear to be associated with the piping. In 26-TP-511, the soil staining started at a coupling between sections of the 12-inch ceramic pipe and spread laterally with depth, extending to the depth of exploration (11 feet). A small area of stained soil was observed beneath a coupling in the 4-inch ceramic pipe at a depth of 3 feet along the south wall of test pit 26-TP-513. Similar staining was observed between depths of 4 to 10 feet along the west wall of the test pit, but it was not continuous with the staining next to the pipe and did not appear to be related to the 4-inch ceramic pipe. No other piping was observed in this test pit. Soil at test pit locations 26-TP-11 through 26-TP-13 and 26-TP-15 was later excavated to a depth of 3 to 4 feet during ISR.

Deteriorated, stained gravels were also observed in the upper 3 feet of 26-TP-514 (no pipes were observed). The upper 2 feet of silty sand in this test pit was interbedded with a colored, ash-like material. At a depth of 7 feet, cemented gravels were found; they appeared to be native—not concrete or other man-made material. Several unsuccessful attempts to penetrate the material were made, including enlarging the test pit. The material was too dense to be sampled, even using the backhoe. This condition was not observed in any other exploration on site.

2.12.3 Constituents in Soil

Laboratory analyses performed on soil samples from Area 26 included up to nine metals, TPH (non-Bunker C), explosives, SVOCs, and PAHs. All of these analytes were detected in at least one sample from Area 26. Many of these samples were removed during 1999, 2000, and 2001 ISRs and are no longer representative of current site conditions. Two phthalate compounds, detected in a single sample, were the only SVOCs detected in any of the samples. Analyses were also performed for Bunker C fuel, diesel, gasoline, kensol, kerosene, and Stoddard solvent in two selected soil samples. These compounds were not detected in either sample.

Tables B.9-1 through B.9-5 in Appendix B present an overview of the RI soil sampling results from Area 26. Figure 2.12-1 shows the sampling locations.

ISR work conducted in Area 26 is described in Sections 2.20.15 and 2.20.16.

2.13 AREA 31—BURNING GROUND SOIL QUALITY

2.13.1 History of Activities

Materials from the Site were burned for many years at this location. Within a fenced area of the burning ground, 6 to 24 inches of highly variable material overlying sandy gravel soils were uncovered during the pre-RI field work. This material consisted of black, ash-rich, tar-like residue with rusting iron, glass, ceramic fragments, and varying amounts of lead debris. A mound of burned residual materials was present in the center of the burning ground. Visible lead debris and lead-coated steel grating and bricks were also observed within a 10- by 100-foot area. Solid debris, including rusting metals and ceramics, was observed adjacent to and north of the

burning ground during pre-RI investigations. Several partially buried drums were located in a depression (ravine) south of the burning ground. Other buried materials included charcoal, ash, bricks, glass, auto body parts, and pipes.

Fifty-four soil samples were collected from 21 test pits, 1 boring, and 2 surface locations during the pre-RI work. The pre-RI soil samples had elevated concentrations of DNT, TNT, lead, and cPAHs.

2.13.2 Soil Conditions

Debris and/or fill material was encountered in RI test pits 31-TP-501, 31-TP-502 (1 to 3 feet of soil was later excavated from this location during ISR) and soil boring 31-B-501 (3 feet of soil was later excavated from this location during ISR), all within the burning ground, and in 31-TPH-508, which was excavated during ISR of the Area 31 ravine. Debris consisted of brick fragments, lead debris, nails, scrap metal, and glass. Depth to water in the five RI borings ranged from 17 to 22 feet below ground surface.

2.13.3 Constituents in Soil

Laboratory analyses performed on soil samples from Area 31 included up to 10 total metals: TPH, explosives, SVOCs, PAHs, and PCBs. All of these analytes, except for PCBs, were detected in at least one sample from Area 31. TPH was detected once at a concentration near the detection limit and the result was therefore qualified. In addition, the only SVOC detected was bis(2-ethylhexyl)phthalate, in three samples at concentrations near the detection limit; these results were also qualified. PCBs were not detected in any samples from this area.

Tables B.10-1 through B.10-6 in Appendix B detail the soil sampling explorations and depths of sample collection and summarize the soil quality data in Area 31. Figure 2.13-1 shows the sampling locations.

ISR efforts in 1999, 2000, and 2001 removed the majority of the elevated concentrations in Area 31. ISR work for this area is described in Sections 2.20.8, 2.20.13, 2.20.14, and 2.20.15.

2.14 AREA 38—CARTON PRODUCTION AREA AND DRYWELL SOIL QUALITY

2.14.1 History of Activities

Area 38 encompasses the buildings used for production and labeling of the cartons used to package and ship the products from the Site. Packaging materials were originally wooden boxes, which over time were replaced by paraffin (wax)-coated cardboard cartons. Both cardboard printing and paraffin coating activities occurred in this area. Water and/or solvents used to clean printing equipment in the box factory reportedly drained through a wooden trough from the building into a drywell, which is an approximately 3-foot-square, 7-foot-deep, wood-lined location approximately 15 feet south of the box factory.

Five surface samples were collected in Area 38 as part of the pre-RI sampling program. Elevated lead concentrations were observed in the pre-RI samples from beneath the trough and the drywell bottom.

2.14.2 Soil Conditions

Subsurface explorations were conducted within the drywell (38-B-501) and beneath the trough that leads from the box factory to the drywell (38-TP-501).

Soil boring 38-B-501 was advanced to a depth of 16 feet below the drywell bottom (23 feet below grade). A gray, fine-grained non-native fill material with a noticeable sulfur smell was encountered in the first 2 to 3 feet below the drywell bottom. Steilacoom Gravels with minor silt were encountered below this material to the depth of exploration.

Fill containing wood debris, copper wire, and ACM was encountered to a depth of 6 feet below grade in 38-TP-501. The ACM observed in the test pit was removed by TLH Abatement Inc. and disposed of at Thun Field Landfill in Puyallup, Washington. The debris fill was localized to a 3- to 4-foot-wide area immediately beneath the surficial wooden trough. Undisturbed Steilacoom Gravels were observed on either side of the fill and beneath it (below 6 feet).

2.14.3 Constituents in Soil

Laboratory analyses performed on soil samples from Area 38 included up to 14 total metals, TPH, diesel, gasoline, explosives, VOCs, SVOCs, PAHs, and pesticides. Total metals, TPH, SVOCs, and PAHs were detected in at least one sample from Area 38. Results from the paraffin investigation (Hart Crowser 1996) indicated that the TPH in Area 38 was diesel-range and oil-range TPH, not paraffin. Many of these samples were removed during 1999, 2000, and 2001 ISRs and are no longer representative of current site conditions. The only SVOCs detected were two phthalate compounds, each detected in single samples. The detected concentrations were near the detection limits; therefore, these results were qualified. Explosives, VOCs, diesel, gasoline, and pesticides were not detected in any samples from Area 38.

The RI soil quality data and associated sampling depths in Area 38 are summarized in Tables B.11-1 through B.11-7 in Appendix B. Sampling locations are shown in Figure 2.14-1.

ISR work conducted in Area 38 is described in Sections 2.20.11 and 2.20.16.

2.15 AREAS OF POTENTIAL CONCERN SOIL QUALITY

In response to Ecology comments, the Sampling and Analysis Plan for the APs provided in the Management Plan (Hart Crowser 1992a) was expanded to include test pits at one or more locations within each AP, as discussed in Hart Crowser (1992b).

Laboratory analyses were performed on soil samples from the seven APs (AP-A through AP-G). Results from these analyses are discussed separately in the following subsections.

2.15.1 AP-A Powder Test Ground

History of Activities

Area AP-A was defined to address a former “powder test ground” (explosives detonation area) that operated during the 1950s and 1960s. Specific features associated with the area no longer exist. The test ground, as shown on a 1955 historical map, measures approximately 125 by 75 feet. The test ground was located near the western plant boundary, west of the main powerhouse

within the CDB. A review of aerial photographs suggested two possible areas that corresponded to the 1955 historical map location: one immediately west of the former nitrostarch nitrating building (Area AP-C) and the other farther west within the CDB. The latter correlates with distances from nearby structures, as shown on the historical map, but is not observed as a distinct clearing in aerial photographs (as is the former location).

Before locations were staked for the RI sampling, an extensive field reconnaissance of the area was conducted. No indication of features potentially associated with historical testing was evident other than a location south of the area, which appeared to be unnaturally flat. Explorations were located to provide coverage of both potential areas and the flat area to the south. The exploration locations are shown in Figure 2.15-1.

Soil Conditions

During the RI, one test pit was completed and two surface samples were collected in AP-A. Undisturbed Steilacoom Gravels were encountered to a depth of 5 feet in APA-TP-501 (Figure 2.16-3).

Constituents in Soil

Laboratory analyses performed on soil samples from Area AP-A included total metals and explosives. Both analytes were detected in at least one sample from Area AP-A. Analytical data for soil samples collected from AP-A during the RI are presented in Tables B.14-2, and B.12-1 through B.12-7 in Appendix B. Sampling locations are shown in Figure 2.15-1.

2.15.2 AP-B Smokeless Powder Dump

History of Activities

Smokeless powder, which consisted of nitrate, cellulose, NG, and plasticizers, was stockpiled in three structures in this area between World War I and 1928. Two test pits were sampled in this area during the pre-RI sampling (Site 22 in Hart Crowser 1987). NG was not detected in the sample from either pre-RI test pit.

Soil Conditions

During the RI, two test pits and two surface samples were completed in AP-B. Undisturbed Steilacoom Gravels were encountered in both APB-TP-501 (later excavated to a depth of 5 feet during ISR) and APB-TP-502. Bricks were observed at the surface approximately 20 feet west of the APB-TP-502 location, and they were the reason the exploration was located there. Short stakes and string were also observed around the bricks, indicating possible archaeological excavations in conjunction with a reported historic oxen trail running through this area to Puget Sound. Prior to excavation at this location, field personnel conferred with archaeologist Dr. Richard Daugherty of Western Heritage, who gave permission for excavation to proceed. No cultural resources were observed in the immediate vicinity either in the excavation or on the surrounding surface. The exploration locations are shown in Figure 2.15-2.

Constituents in Soil

Laboratory analyses performed on soil samples from Area AP-B included explosives and nitrate. Nitrate was detected in at least one sample from Area AP-B. Explosives were not detected in any samples from this area. The soil quality data are summarized in Tables B.12-1 through B.12-7 in Appendix B.

2.15.3 AP-C Smokeless Powder Nitrating/Grinding House***History of Activities***

Between 1916 and 1928, nitration of nitrocellulose and nitrostarch was conducted in this building. During the same time period, smokeless powder pellets were ground into fine powder for use as an admixture in the dynamite process.

Soil Conditions

During the RI, two test pits and one observational test pit were completed, and 14 surface samples were collected in AP-C. Undisturbed Steilacoom Gravels were observed in APC-TP-501, and later excavated during ISR to a depth of 5 feet. At the time of sampling, small pieces of lead debris were observed on the Nitrating/Grinding House foundation and on the ground adjacent to the foundation. Review of the architectural plans and sections for this building indicated possible lead lining in a portion of the former building. As a result, additional surface samples (APC-SS-505 through APC-SS-514; surficial soil at locations APC-SS-505 through APC-SS-509 was later excavated during ISR) were collected and analyzed for lead. Test pit APC-TP-502 was excavated at the mixed acid storage area to evaluate metals concentrations at depth, and later it was excavated to a depth of 1 to 3 feet during ISR. Some bleached gravels were observed between depths of 1 and 7 feet in this test pit. The exploration locations are shown in Figure 2.15-1.

Historical architectural plans indicated that a “sump well” might be present adjacent to the southwest corner of the nitrator foundation. Observational test pit APC-TP-503, covering a surface area of approximately 30 by 18 feet, was excavated to a depth of about 4 feet in this area to look for subsurface evidence of this feature (Figure 2.15-1). No evidence of a sump well was observed in the large excavation.

Demolition debris (mostly wood) was observed at the surface in the location of the northern room of the Nitrating/Grinding House, which was pile-supported.

Constituents in Soil

Laboratory analyses performed on soil samples from Area AP-C included total metals, explosives, and nitrate. All three parameters were detected in at least one sample from Area AP-C. Many of these samples were removed during 1999, 2000, and 2001 ISRs and are no longer representative of current site conditions. The soil quality data for the AP-C area are summarized in Tables B.12-1 through B.12-7 in Appendix B. Sampling locations are shown in Figure 2.15-1.

2.15.4 AP-D Asphalt Paint Building

History of Activities

This building was used prior to the 1940s for heating asphalt for coating structures such as the NG gutters in the NG production area. Although called an asphalt paint “kettle” on historical maps, the term kettle at this building refers to the melting pot and facility function, rather than to a glacial kettle (geologic depression), as the term is used elsewhere in this report.

Soil Conditions

During the RI, one test pit was completed in AP-D. AP-D occurs within an area covered with a veneer (0 to 2 feet thick) of disturbed soils, crushed rock, and demolition debris (e.g., bricks and mortar). There was no surficial evidence of the former Asphalt Paint Building in the vicinity. The extent of this demolition debris was discussed in Sections 2.11 and 2.12.

To look for subsurface evidence of the building foundation, APD-TP-501 was excavated along an approximately 20-foot length in the location of the former building, as determined from historical maps (Figure 2.12-1 and Tables B.9-1 through B.9-5 in Appendix B). Fill with demolition debris similar to the surface materials was observed to a depth of 3 feet in this excavation. Occasional small pieces of hard tar-like material and lead debris were observed in the upper 6 inches of fill. Native Steilacoom Gravels were observed below a depth of 3 feet. Due to the significant surface disturbance, the proposed surface samples APD-SS-501 and APD-SS-502 were not collected.

Constituents in Soil

Laboratory analyses performed on soil samples from Area AP-D included total metals, TPH, explosives, SVOCs, and PAHs. Total metals, TPH, and PAHs were detected in at least one sample from Area AP-D. Explosives and SVOCs were not detected in any samples from this area. Analytical data for soil samples collected from AP-D during the RI are presented in Appendix B, Tables B.12-1 through B.12-7.

2.15.5 AP-E Main Transformer House

History of Activities

Although two powerhouses were located at the plant, the Puget Sound Power and Light Company was its main source of electrical power. The transformer house served as the main power and switching yard throughout the period of manufacturing operations.

Soil Conditions

During the RI, 2 test pits and 13 surface samples were completed in AP-E. Bricks and demolition debris are scattered around the surface of the former Main Transformer House. In APE-TP-501, located immediately adjacent to the building foundation, 6 inches of the brick debris was underlain by a 2- to 3-inch layer of black silty soil, which was underlain by

Steilacoom Gravels to a depth of 5 feet. In APE-TP-502, excavated along the eastern edge of the foundation, native soils were observed beneath approximately 1.5 feet of sandy gravel fill. Some debris from the foundation was also observed down the slope in the vicinity of surface soil sample location APE-SS-501.

Constituents in Soil

Laboratory analyses performed on soil samples from Area AP-E included total metals, TPH, and PCBs. Total metals and TPH were detected in at least one sample from Area AP-E. Many of these samples were removed during 1999, 2000, and 2001 ISR and are no longer representative of current site conditions. PCBs were not detected in any samples from this area. Analytical data for soil samples collected from AP-E during the RI are presented in Tables B.12-1 through B.12-7 in Appendix B. Sampling locations are shown in Figure 2.15-3.

2.15.6 AP-F Nitrocotton Area

History of Activities

Drying and screening of nitrocotton fibers as additives to the dynamite process were conducted in this area from the early years of production until their use was discontinued in 1960. The facilities were burned as part of the plant decommissioning.

Soil Conditions

During the RI, 1 test pit, 1 hand-augered boring, and 23 surface samples were completed in AP-F. Metal and wood debris was observed at the surface within the berms surrounding the Nitrocotton Dry House (APF-TP-501) and the Dry Cotton Store House (APF-SS-502). Debris was not observed below grade in APF-TP-501, where Steilacoom Gravels were observed to a depth of 5 feet.

Constituents in Soil

Laboratory analyses that were performed on soil samples from Area AP-F included metals, explosives, and nitrate. Metals and nitrate were detected in at least one sample from Area AP-F. Many of these samples were removed during 1999, 2000, and 2001 ISR and are no longer representative of current site conditions. Explosives were not detected in any samples from this area. Analytical data for soil samples collected from the AP-F during the RI are presented in Tables B.12-1 through B.12-7 in Appendix B. Sampling locations are shown in Figure 2.15-4. Based on site characterization results, detectable lead, barium, and chromium remain in this area.

2.15.7 AP-G Decontamination Areas

History of Activities

Plant equipment was cleaned of incidental residual NG and residual explosives at a decontamination facility from at least the late 1950s through the early 1970s. Decontamination

consisted of hot water washes, application of NG remover (alcohol, acetone, and sodium sulfide), and neutralization with either glycerin or diethylene glycol.

Two areas near the maintenance shop facilities were identified as locations of possible equipment cleaning activities. Field efforts to identify the first (referred to as the southern unit) located demolition debris (bricks and concrete foundation) at the location.

The second (referred to as the northern unit) appeared on historical maps from the 1950s labeled as the “decontamination bath.” Scaled distances from the map suggested a location in this area slightly northwest of an existing large rectangular concrete slab. Review of the 1961 aerial photograph identified a small, square structure located where a small, square concrete slab now exists. The aerial photograph indicates equipment was originally stored on a graded area to the north and was subsequently stored on the large rectangular concrete slab. This decontamination facility remained on the Site up to the time of plant decommissioning. Remaining features include the laydown slab and the smaller, square concrete slab that served as the foundation for the decontamination structure.

The southern unit was identified as Site 23 in the pre-RI, although both areas subsequently were tested. NG, TNT, and DNT were not detected in samples from either pre-RI test pit. Based on a review of prior sampling efforts and information from additional aerial photograph review, additional tests during the RI appeared to be warranted and the two localities were redesignated as AP-G.

Sampling locations focused on proximity to structural features and areas susceptible to runoff collection from cleaning operations. In addition, a test pit (APG-TP-502, discussed below, and later removed during ISR work) was excavated at the more northwestern location identified through historical mapping to ascertain whether activities could have occurred at this location rather than at the more obvious confirmed features.

Soil Conditions

During the RI, three test pits and one observational test pit were completed, and three surface samples were collected in AP-G. In the northern unit, a variety of equipment and scrap metal was being stored on the large rectangular concrete slab next to APG-SS-501 and APG-SS-502. Some scrap metal and piping were also stored on the smaller, square concrete slab adjacent to the southeastern corner of the large slab.

Steel rebar and electrical wiring were observed in the upper 2 feet of APG-TP-504, excavated between the large and small slabs (Figure 2.15-3). A 1-inch-diameter steel water supply pipe was encountered 1.5 feet below grade in APG-TP-501, excavated within a shallow swale leading away from the area. Other than the piping and wiring, only Steilacoom Gravels were observed in these two test pits.

APG-TP-502 (an observational test pit, where no samples were collected) was excavated in a very small depression (apparently natural) at the location northwest of the rectangular concrete slab. This excavation was conducted to look for any evidence of the former decontamination bath structure, and thereby confirm the more recent interpretation of the historical aerial photographs, which indicated that the bath was located at the small northern slab. There were no surficial indications of a structure or other man-made disturbance anywhere in the vicinity of

APG-TP-502. Similarly, there were no indications of subsurface disturbance noted in the excavation.

APG-TP-503 was excavated next to the former building (concrete foundation and bricks remaining) in the southern unit (Figure 2.16-3). Native Steilacoom Gravels were encountered to the 5-foot depth of exploration in this excavation. APG-SS-503 was completed in a shallow natural depression downslope of the former building.

Constituents in Soil

Soil samples from Area AP-G were analyzed for explosives and metals. Explosive compounds were not detected in any samples from this area. Analytical data for soil samples collected from AP-G during the RI are assigned to the Site Reference Area and presented in Tables B.14-1 and B.14-2 in Appendix B. All AP-G sampling locations are shown in Figure 2.16-3.

ISR in the AP areas was conducted in areas AP-B and AP-C as described in Section 2.20.16.

2.16 SITE REFERENCE AREA SOIL QUALITY

The Site Reference Area includes the portion of the Site that lies within the CDB but outside the production/disposal areas that received more detailed environmental characterization. Two exceptions are a reference grid of surface samples in Areas 18 and 31 (Area 18-Reference and Area 31-Reference), which were analyzed for arsenic and are included in this section to allow a better understanding of the distribution and sources of arsenic on a Sitewide basis (Figures 2.16-1 and 2.16-2 and Tables B.13-1 and B.13-2). Historical research has not identified any activities or manufacturing processes that would impact the soil quality in these outlying areas. Historical activities in the Site Reference Area were primarily restricted to transportation corridors.

Due to the elevated lead concentrations in many areas of the Site, soils beyond the designated production facilities and disposal areas were evaluated for lead. Similarly, elevated arsenic concentrations were found in peripheral areas, apparently unrelated to specific production or disposal areas. Therefore, arsenic was evaluated using a systematic Sitewide investigation.

Surface (0- to 6-inch depth) samples were collected from 70 locations in the Site Reference Area and analyzed for lead. Later, these same locations, as well as an additional 23 reference locations in Area 18, were resampled for arsenic. Because elevated arsenic concentrations were frequently encountered in the soil samples and the arsenic distribution was not well defined after the initial round of sampling, more comprehensive arsenic sampling was subsequently conducted in the Site Reference Area. An additional 485 surface samples and 48 subsurface samples (to a 2-foot depth) were collected to better define the Sitewide distribution of arsenic.

2.16.1 Lead

The Site Reference Area was systematically sampled on a staggered grid of 500-foot centers (Figure 2.16-3). Surface samples were analyzed for lead (Lead Reference [LR] Area) using both XRF and atomic absorption (AA) techniques. Subsequently, the five highest concentrations (in samples LR-19, LR-38, LR-62, LR-68, and LR-102) were crossed with additional samples offset by 125 feet to assess the spatial extent of lead in these locations.

Following initial review of the data, more detailed assessments were completed in the area of samples LR-68 and LR-62.

XRF Versus AA Lead

Surface soil samples were screened in the field with a portable XRF probe calibrated to Site soils. Twenty-five samples were selected at random and submitted to a laboratory for confirmation analyses by AA. The five highest XRF readings were also submitted for confirmation analysis. Lead determinations by XRF and AA are well correlated ($r^2 = 0.90$) and support the use of XRF as a screening tool.

Two samples (LR-91 and LR-104) were classified as outliers and omitted from the correlation because XRF and AA results differed for these samples by an order of magnitude. The discrepancy likely resulted from inherent differences in the analytical techniques: XRF measures a surface area of the soil, whereas AA is a volumetric extraction. In addition, XRF is probably more susceptible to high bias imparted by random sampling of small pieces of particulate lead. In both of the outlier samples, the laboratory results were substantially lower than the field screening results, so omission of these samples is conservative in terms of using the regression to predict lead concentrations based on XRF screening.

XRF and AA data were combined to evaluate data during Site characterization. AA lead determinations were preferentially used where laboratory confirmation data exist; otherwise, XRF values were used. The use of XRF data is likely conservative because the regression model suggests that screening values tended to overestimate the analytical lead concentrations. For example, an XRF value of approximately 400 mg/kg equates to an analytical lead concentration of 250 mg/kg (as predicted, on average, by the regression model). Although screening data proved useful during Site characterization, they were not retained in the database developed for this RI (Pioneer 2002).

Spatial Distribution of Lead

Most of the elevated lead concentrations occur along the perimeters of designated production areas in the north-central part of the Site and are likely derived from these adjacent facilities (Figure 2.16-3).

2.16.2 Arsenic

Soil arsenic concentrations above site-specific background levels (i.e., 33 mg/kg) were observed in unrelated areas across the Site. Many of the results showed no apparent relationship to production facilities, disposal sites, or specific point sources. In order to evaluate the potential Sitewide distribution of arsenic, the Site Reference Area and Area 18-Reference were sampled on 500-foot centers for arsenic. Table B.14-1 and B.13-1 in Appendix B present analytical results for arsenic in the Site Reference Area and Area 18-Reference, respectively. Initial results from the 500-foot grid indicated that moderately elevated arsenic concentrations range across the Site.

Subsequently, a comprehensive Sitewide sampling program targeting the source and distribution of arsenic was implemented. This program included the following elements:

- **Grid Sampling of the Site Reference Area on 250-Foot Centers.** The Site Reference Area was sampled using a higher resolution grid (303 samples, including the original 500-foot grid samples). The grid was also extended into the Area 18-Reference (124 samples) (Figure 2.16-1).
- **Fine-Scale Grid Sampling in Two Areas.** A second phase of fine-scale grid sampling (10- to 125-foot centers) was conducted in two areas where relatively high arsenic concentrations were observed based on the 250-foot grid. One area of detail is located just south of Area 26, and the other area is located in the central part of the Area 18-Reference (120 samples).
- **Depth Sampling at Selected Locations.** At grid locations with elevated arsenic, hand-augered samples were collected from subsurface depths to define the vertical extent of arsenic in Site Reference Area soils (52 samples).
- **Arsenic Speciation Analyses.** Soil samples with known elevated arsenic concentrations from various areas were submitted for speciation analyses in an attempt to identify potential arsenic source(s) (6 samples).
- **Sampling of Utility Corridors and Motor Houses.** To evaluate the hypothesized use of arsenical herbicides for weed control, two cleared utility corridors on the bluff were sampled (16 samples). In addition, surface soils near several motor houses in Area 18 were sampled (8 samples).
- **Sampling of Railroad Grades.** Both narrow-gauge and standard-gauge railroad grades were extensively sampled for arsenic, and selected locations were sampled for lead. These results are presented in a separate discussion (see Sections 2.17 and 2.18). The data indicate that standard-gauge railroad samples and samples collected 50 or more feet from the narrow-gauge tracks were not statistically different from the Site Reference Area samples; therefore, these samples were included in the Site Reference Area (84 samples).

Spatial Distribution of Arsenic

Grid sampling for arsenic on 250-foot centers did not reveal clear or consistent distribution patterns. The following general observations can be made, although exceptions occur:

- Elevated arsenic concentrations are found in some stretches along the property boundary, particularly near the main gate on the southeast boundary, and along the bluffs northwest of Area 18.
- Elevated arsenic concentrations are found near the periphery of certain areas with known elevated arsenic concentrations.
- Elevated arsenic concentrations appear to be locally related to edge effects from railroad corridors, e.g., along the mainline track, which follows the southern bank of Sequelitchew Creek, just inside the eastern boundary of the site (note, however, that samples within 25 feet of the narrow-gauge tracks were not included in the Site Reference Area [see Sections 2.17 and 2.18]).
- Arsenic concentrations are apparently reduced in areas where ISR has disturbed surface soils (e.g., the northern part of Area 18/1/2/3/4).

Fine-scale sampling at 10-foot and 25-foot intervals did not identify any clearer spatial relationships. Alternately high and low concentrations occurred even among closely spaced samples.

Vertical Distribution of Arsenic

Hand-augered borings were completed in 26 locations on the reference grid to delineate the vertical extent of arsenic in soils. Hand-auger locations were selected on the basis of elevated surface concentrations (ranging from 82 to 390 mg/kg) as well as to provide representative coverage across the Site. Subsurface samples were collected at 0.5- to 1-foot and 1- to 2-foot-depth intervals to complement existing surface samples at a 0- to 0.5-foot depth.

Results of the subsurface sampling indicate that elevated arsenic concentrations are largely restricted to the upper 6 inches of soil. Elevated arsenic concentrations were infrequently encountered at depth.

Arsenic Speciation Analyses

Three samples with high total arsenic concentrations from the Site Reference Area and three samples from other Site areas with elevated arsenic concentrations were submitted to the Battelle Laboratory in Sequim, Washington, for arsenic speciation analyses, in an attempt to identify potential arsenic source(s). Arsenic speciation analyses quantified the oxidized (As-V) and reduced (As-III) forms of inorganic arsenic, as well as organic (methylated) arsenic species.

Speciation analyses indicated that arsenic is largely present in its oxidized state (As-V). The common reduced form of arsenic (As-III) accounted for less than 1 percent of the total soil arsenic. In addition, organic (methylated) arsenic accounted for about 4 percent of the total soil arsenic in one sample (LR-104). Both inorganic arsenic acid (As-V) and methylated forms of arsenic acid are used in the formulation of arsenic-based herbicides. Inorganic arsenic-based herbicides are more persistent, whereas organic forms are more readily decomposed. Potential arsenic sources are discussed further in the subsection "Sources of Sitewide Arsenic."

Utility Corridors and Motor Houses

To further evaluate and substantiate the potential historical use of arsenic-based herbicides to control weeds and reduce fire hazard, two utility corridors along the coastal bluffs ("UC-" sample designation, assigned to Site Reference Area, Table B.14-1, Figure 2.16-3) and several motor houses in the Area 18 dynamite production area ("MH-" sample designation, assigned to Area 18, Table B.7-1, Figures 2.10-2 and 2.10-3) were sampled for arsenic.

Results from the utility corridor sampling indicated that moderate concentrations of arsenic (19 to 88 mg/kg) are present in the soil (see Figure 2.16-3). However, soil arsenic concentrations within the corridors, where weed control may have been conducted, are not significantly different from soil concentrations in samples collected outside of the corridors in adjacent vegetated areas. Arsenic concentrations in the utility corridor samples are slightly elevated relative to concentrations in samples from the Site Reference Area. These data do not suggest that utility corridors received above-average herbicide applications. Vegetation in the corridors was possibly controlled by hand.

Results from the motor house sampling indicate that locally high arsenic concentrations (up to 460 mg/kg) are present in the immediately surrounding soil. Seven of eight sample concentrations were elevated. Particularly high arsenic concentrations were detected in samples from motor houses adjacent to the Gelatin Box Packing House No. 2 (140 mg/kg, 18-MH-4, Table B.7-1, Figure 2.10-2), and the Gelatin Cartridge House No. 1 (460 mg/kg, 18-MH-1, Table B.7-1, Figure 2.10-3). Because of their sparking potential, motor houses constituted fire hazards and were, therefore, isolated from the actual dynamite production facilities. These data suggest that motor houses may have received arsenic-based herbicide applications to keep the areas weed free and thereby minimize the potential for fires.

Sources of Sitewide Arsenic

The use of arsenic-based herbicides throughout the Site as an arsenic source is consistent with the available data. According to a former DuPont employee, fire prevention was a primary concern at the Site, particularly in areas where the explosive hazard was high. Weed control through herbicide application was a main component of the facility maintenance program, although the specific compositions of the herbicides used on the Site are not known. Arsenic-based herbicides were commonly used from the early 1900s.

The use of arsenic-based herbicides to reduce fire and explosive hazards is consistent with the following observations and analyses:

- Moderate concentrations of arsenic are widespread throughout the Site and not specifically associated with production activities.
- Arsenic concentrations are spatially heterogeneous and vary over short distances, consistent with the patchy distribution that might result from localized spray applications.
- Elevated arsenic concentrations are surficial in nature and largely confined to the upper 6 inches of soil.
- Speciation analyses indicate that most arsenic is present in an oxidized, inorganic form, such as arsenic acid, which was a common formulation for arsenic-based herbicides.
- Elevated arsenic concentrations are found in Area AP-E (the transformer house), in Area AP-F (the nitrocotton storage), in certain parts of Area 18 (i.e., near the packing houses and motor houses), and in the detail grid south of Area 26 (near the pulp drying houses)—all areas of potential fire and explosive hazard.
- According to a former DuPont employee, herbicides were stored in a warehouse in Area 38; elevated arsenic concentrations were found in Area 38, including in soil adjacent to both of the storage buildings on the east side of the box factory.
- Elevated arsenic concentrations are consistently found along the narrow gauge railroad tracks, which were maintained by DuPont crews, because it was very important to keep explosives transportation corridors free of fire hazards (see Section 2.17).

Arsenic was also a likely by-product of the burning of pyrite during the acid production process. Pyrite originates in sulfide deposits, which can contain arsenic. Arsenic could occur in association with the pyrite burning process or disposal associated with the acid production area. This source may account for elevated arsenic concentrations in Areas 25, 5, and 16. In

particular, arsenic associated with liquid waste conveyed in discharge pipes to the adjacent kettle (Area 5/16) is associated with the subsurface occurrence of arsenic in these areas, which is unique relative to the surficial distribution of arsenic elsewhere on the Site.

Unsubstantiated Sources of Arsenic

Other sources of arsenic have been considered but are not substantiated by constituent testing results and do not appear to be supported by Sitewide arsenic distribution.

Facility decommissioning could have contributed arsenic to soils around buildings if arsenic-based paints were used. Twenty-six samples of building paint were analyzed, and only two samples contained elevated arsenic (810 and 2,800 mg/kg); the remaining samples contained concentrations near or below the detection limit of 50 mg/kg. In addition, elevated arsenic concentrations do not appear to be localized around building foundations. Because only a small percentage of historic building paints contained appreciable arsenic, the paint appears to be an unlikely source.

Three sulfur samples were tested for arsenic impurities, since arsenic may be associated with sulfur ore deposits; however, the results ranged from nondetections to 7 mg/kg. Ten railroad ties were analyzed to determine whether they may have been treated with arsenic-based wood preservative. Low to moderate concentrations of arsenic (maximum of 120 mg/kg) were detected in the tie samples (see Section 2.17), indicating that the ties likely received arsenic during surficial herbicide applications along the rail lines, but were not dipped in arsenic-based preservative. During Site sampling, hand trenching of the railroad grades at 10 locations was conducted to determine whether fill material might have been added to the railroad grade and could potentially be a source of arsenic. The trenching activities indicated slag-like material was not used as grade foundation, but rather the railroad grades were constructed with local Steilacoom Gravels. A former DuPont employee indicated that approximately 1 percent arsenic was commonly added to strengthen lead sheathing and fixtures used in the production facilities. However, arsenic concentrations are not elevated at the Lead Melt House (Area 36), and the presence of arsenic and lead, in general, is not correlated at the Site.

Analytical data for soil samples collected in the Site Reference Area during the RI are presented in Tables B.13-1 through B.13-2 and B.14-1 through B.14-4 in Appendix B (except as noted in the section “Utility Corridors and Motor Houses”). Figures 2.16-1 through 2.16-3 show the sampling locations (except as noted in the section “Utility Corridors and Motor Houses”).

ISR work conducted for lead and arsenic hot spots in 1999, 2000, and 2001 removed the majority of the elevated concentrations. The ISR work is described in Sections 2.20.15 and 2.20.16. Following ISR, mercury remains in the Area 31-Reference Area.

2.17 HISTORICAL RAILROAD GRADES SOIL QUALITY

2.17.1 History of Activities

Two types of railways served the areas within the Site during its operation. An NGRR connected the various production and material storage areas within the facility. A standard gauge railway, operated by the Northern Pacific Railroad, brought raw materials to storage facilities in the plant (e.g., in the acid production and black powder production areas) and

transported finished products from the plant. Many of the rails (both narrow- and standard-gauge) were removed during facility decommissioning, but the railroad grades remain in most locations. The locations of the historical narrow-gauge and standard-gauge grades are shown in Figure 2.17-1.

Surface soils along narrow-gauge and standard-gauge railroad grades within the Site were sampled for arsenic at approximately 500-foot intervals. Based on these results, selected stretches of the grades were sampled at 100-foot intervals to evaluate more detailed spatial variability in arsenic concentration; samples were also collected at 25- and 50-foot distances from the edges of the grades to evaluate arsenic concentrations laterally away from the grades. Based on surficial (0 to 0.5 foot) arsenic concentrations, samples were collected at depth (0.5 to 1 foot and 1 to 2 feet) at 20 locations and analyzed for arsenic. In addition, lead analyses were conducted on the grades on 20 surface soil samples and 6 samples from depth.

Figure 2.17-1 shows all railroad grade sampling locations and arsenic concentrations from surface samples (0 to 0.5 foot). Tables B.15-1 and B.15-2 in Appendix B provide all data for the railroad grade samples.

2.17.2 Soil Conditions

Steilacoom Gravels were encountered at all sampling locations along both the narrow-gauge and standard-gauge grades. The Steilacoom Gravels were used as fill in those portions of the grades that were built up. No non-native fill materials were observed during the RI.

2.17.3 Constituents in Soil

Elevated arsenic concentrations are located on portions of the narrow-gauge and standard-gauge grades. Elevated lead concentrations were also found in four sampling locations. Many of these samples were removed during 1999, 2000, and 2001 ISRs and are no longer representative of current site conditions.

Laboratory analyses that were performed on Site Reference soil samples from the Historical Railroad Grades included lead and arsenic, as discussed above. Up to 12 other total metals, gasoline, diesel, and TPH were also analyzed in five soil samples. Total metals and gasoline were detected in at least one sample from this area. Diesel and TPH were not detected in any samples from this area.

2.17.4 Distribution of Constituents in Soil

Arsenic in Surface Soils

The sampling results indicate that surficial (0 to 0.5 foot) arsenic concentrations are substantially higher on the narrow gauge grades than on the standard-gauge grades.

Interviews with former DuPont employees indicated that the NGRRs historically have been sprayed with herbicides to control weeds as a fire-protection measure. The general consistency in elevated arsenic concentrations along the NGRR grades supports focused application of arsenic-based herbicide as a likely source for the detected arsenic.

The distribution of arsenic along individual stretches of the narrow-gauge lines appears to relate closely to (1) when a line was used, (2) how long a line was used, and (3) whether explosive compounds were handled on or near the line. These generalized patterns are apparent when segmenting the railway corridors and associated arsenic data into functional/temporal areas. Higher surficial arsenic concentrations correspond to the primary production lines and transportation routes (e.g., Area 18 powder lines used for the longest period of time [Gel Mix 1 Line and Dynamite Mix Lines 1 and 2] and the transportation loop connecting the finished product storehouses and the burning ground). These facilities were operated the longest. Other production lines operated for shorter periods of time, such as the Smokeless Powder Line and the Gel Mix 3 Line, show considerably lower arsenic concentrations. Based on these data, the following observations can be made:

- Detected arsenic concentrations likely relate to application of arsenical herbicides to control weeds as a fire protection measure.
- Applications likely occurred between the late 1920s and the early 1960s.
- Concentrations along a specific segment tend to be relatively higher in proximity to manufacturing facilities (with the exception of the primary narrow-gauge shipment line).
- Frequency, concentration, and/or extent of application is greater in explosives manufacturing areas and considerably less for raw materials production areas (e.g., Acid Production Area and the Crystallizer Plant).
- Elevated arsenic concentrations were found at NGRR intersections.
- The standard-gauge railroad apparently did not receive arsenical herbicide treatment due to its infrequency of use, delivery locations, and maintenance by Northern Pacific Railway personnel. Information from a former DuPont employee indicates that the Northern Pacific maintained its rail lines by burning the weeds along the tracks.

Lead in Surface Soils

The NGRR used gas/diesel or electric locomotives at various times during plant operation. The locomotives are possible sources for localized lead concentrations along the railroad grades. Over the duration of railroad use, spot discharges from batteries used in the electric locomotives could have been a potential source for detected lead concentrations. Wear of Babbitt bearings or other metals used for railroad stock could also have been a source for lead on the railroad grades. ISR work conducted in the NGRR corridor is described in Section 2.20.16.

2.18 SEQUALITCHEW CREEK CANYON SOIL QUALITY

2.18.1 2001 Sequalitchew Creek Characterization

This work, completed between January 10, and 16, 2001, was isolated to within, and immediately adjacent to, the NGRR track bed between the site access road and the Burlington Northern Railroad. This RI reports only the data collected between the site access road and the Parcel 1 boundary. Data collected outside the CDB will be the subject of a future report. The

purpose of this work was to determine if arsenic and lead contamination is present. Sampling was conducted as follows:

- Approximately 2,250 linear feet of NGRR track was divided into 75- by 20-foot sections, and a sampling grid was established in each section.
- A field check was made to determine if site conditions justified adjustments to the sampling grid. The sampling sections and locations were referenced to the existing LR-68 sampling location (e.g., the sample that is 75 feet west of LR-68 was labeled LR-68-75W).
- Ecology was contacted. Two Ecology employees visited the work area to determine if any changes to the grid were necessary. No changes were made.
- A five-point composite soil sample was collected within each 75- by 20-foot section.
- 30 samples were collected and taken to Sound Analytical Services for analysis for lead and arsenic (Method 6010).

The analytical results for arsenic and lead are presented in Tables B.16-1 through B.16-5. Figure 2.18-1 shows the sampling locations.

The following conclusions can be made on the basis of these results:

- **Arsenic.** Arsenic was detected in each sample and the concentration consistently exceeded background concentrations. Two locations had elevated concentrations. These locations were excavated and disposed of during the 2001 ISR (see Section 2.20.16).
- **Lead.** Lead was detected in each sample. One location had a very high concentration (9,200 mg/kg). This location was excavated and disposed of during the 2001 ISR (see Section 2.20.16).

2.18.2 Area LR-68 Characterization

During RI grid sampling in the Site Reference Area, elevated lead concentrations were observed about 20 feet downslope of the rail line running along the east bank of Upper Sequatchew Creek. Additional lead samples were collected around the original sample (LR-68) and at 100-foot intervals along the downslope bank of the rail line within the CDB. Two additional locations with elevated lead were discovered along the rail line, southeast of LR-68. There is no documented source at this location in historical records. The source of the metals may be associated with railcar maintenance practices or railcar Babbitt bearings/machinery wear.

Twenty-seven surficial soil samples were collected along the rail line. Miscellaneous debris, including metal, ceramic debris, and bricks, was observed in surficial soils in the vicinity of sample LR-68. No debris was observed in samples collected from depths of 1 to 3 feet or from the two other locations with elevated lead concentrations along the rail line southeast of LR-68.

Laboratory analyses performed on Site Reference Area soil samples from LR-68 included total lead and arsenic, as discussed above.

Soil quality data, associated depths, and analytes for Area LR-68 are summarized in Table B.16-1 through B.16-5 in Appendix B. Figure 2.18-1 shows the sampling locations. (Note that one sample each from LR-68 was assigned to Area 31 and Miscellaneous Areas; these samples are therefore shown in Table B.10-1, Figure 2.13-1 and Table B.19-1, Figure 2.19-4, respectively.)

Although, the majority of the elevated concentrations in the area of LR-68 were removed during the 2001 ISR (see Section 2.20.16), elevated concentrations of lead and arsenic remained. Any remaining impacted soils will be evaluated in greater detail in the RA and FS.

ISR work conducted in the Sequelitchew Creek Canyon is described in Section 2.20.16.

2.19 MISCELLANEOUS AREAS SOIL QUALITY

Additional site characterization was conducted at miscellaneous areas across the Site. These data were collected between 1999 and 2001. The purpose of this work was to further characterize the nature and extent of arsenic and lead impacts in these areas. The additional characterization was conducted in three sets of areas:

- Candidate Areas
- North of Creek Areas
- Miscellaneous Historical Areas

Work in the Candidate Areas was a result of public comment on the Site Environmental Impact Statement (EIS) regarding whether parts of the property could be left in their natural condition without requiring remediation. Sampling in historical areas was focused on the Fort Nisqually Cemetery (45PI404) and the south Shell Midden (45PI72). The remaining characterization was conducted in miscellaneous areas north of the creek associated with the Hot Spot ISR (Section 2.20).

Sampling was conducted as follows for the Candidate Areas and Miscellaneous Historical Areas:

- The soil sampling locations for the three areas were determined relative to the Sitewide 150-foot sampling grid, which extended from the northwest corner of the Site. Ecology and the Project Team agreed that subdividing this larger grid into 75-foot sections was adequate for characterizing these areas.
- The samples were labeled according to their position in the grid (e.g., the sample in row 60 and column 32 was labeled R60C32) and remedial unit (RU) location. The location of each sample was surveyed by ESM Consulting Engineers, LLC (ESM).
- North of the Creek Area characterization sampling locations were determined on the basis of the location of hot spots. Characterization samples were collected from each side of a hot spot excavation in order to confirm that the extent of the excavation was adequate.
- A discrete soil sample was collected at each grid point.
- More than 750 samples (including field duplicates) were collected and taken to Sound Analytical Services for analysis for lead and arsenic (Method 6010).

The analytical results for arsenic and lead are presented in Tables B.17-1, B.18-1, and B.19-1. Figures 2.19-1 through 2.19-4 show the sampling locations for the Candidate Areas, North of Creek Areas, and Miscellaneous Historical Areas, respectively.

2.20 INTERIM SOURCE REMOVAL AREAS

The following interim actions were conducted as allowed under the July 1991 Consent Decree signed by Weyerhaeuser, DuPont, and Ecology. This section briefly describes each ISR. More

details for each ISR action are provided in documents listed in Section 5. ISR areas include Areas 5, 6, 8, 10, 18, 19, 20, 24, 25, 30, 31, 35, 36, 39; the hot spot removal areas; sand laydown areas (SLAs); and the Foundation, NGRR, and topsoil laydown areas.

For the interim actions conducted between 1990 and 1993, DuPont Environmental Remediation Services (DERS) conducted source removals (unless otherwise noted). In many cases Olympus Environmental Services provided excavation services for the work. Hart Crowser provided on-site technical assistance and field oversight to DERS and collected appropriate samples during the interim actions. All soil samples were analyzed at Analytical Technologies Inc. (ATI) and/or the Hart Crowser *FAST* Lab (on-site mobile laboratory), unless otherwise noted.

For the interim actions conducted between 1999 and 2001, Active Construction (ACTIVE) conducted source removals. West Shore Corporation, NW, provided oversight, and sample collection was conducted by URS. All soil samples were analyzed at Multichem or Sound Analytical.

All interim actions were detailed in work plans that were reviewed and approved by Ecology prior to the start of work.

2.20.1 Areas 5 and 6 DNT Waste Drum Areas

Area 5 is the hillside above the Area 16 glacial kettle where discarded containers such as 55-gallon drums, demolition debris, and refuse were placed. During pre-RI work, over 1,000 observable drums were noted. Pre-RI soil characterization sampling and drum contents profiling identified the presence of NAX, TPH, PAHs, acids, metals, isopropanol, and glycol. Area 6 is a ravine located to the east of the Area 5/16 glacial kettle.

The purpose of the interim action in Area 5/6 was to remove, clean, and dispose of drums, debris, fill and impacted soil. DERS performed the work between September 1990 and October 1993, in six phases: drum removal, drum decontamination and recycling, waste debris/soil removal, fill removal and screening, impacted soil removal, and verification soil sampling. Asbestos was encountered at various stages of the interim action and was removed by TLH Abatement, Inc. under the direction of Prezant Associates and DERS.

A total of 4,602 drums were removed from Areas 5 and 6. Of the total, 3,601 were apparently empty, 1,279 contained DNT residual, 3 contained TNT residual, and 259 contained non-NAX contents including petroleum products (oils, tars, grease, glycerin, paraffins, salts, ammonium nitrate, glycol, acids, isopropanol, and rain water). A total of 33 apparently empty drums (one contained paraffin and one contained blasting wire) were found in other areas of the Site.

Area 6 contained approximately 1,600 drums; all but seven of the drums were empty. According to the field screening results, four of the unempty drums contained residual ammonia salts and three contained paraffins (nonhazardous waxes).

RI characterization soil samples were collected after the drum removal around the perimeter of the large volume of debris and fill in Area 5. A small volume of debris in Area 6 was removed during ISR. The sampling results for soil/fill material indicated elevated concentrations of metals, DNT, TPH, and cPAHs. Native soils beneath the fill contained no elevated concentrations.

Approximately 25,050 cubic yards of debris and soil were removed from Area 5 and appropriately segregated, stockpiled, and/or disposed of. Final soil verification samples indicated that all NAX met the target interim action levels.

Numerous characterization, verification, and designation samples were collected and analyzed during each phase of work for this interim action. The ISR in Area 5/6 is reported in Hart Crowser (1994c).

Impacted soils remaining on the Area 5 hillside contain elevated concentrations of one or more of four metals (arsenic, lead, cadmium, and mercury), TPH, and PAHs. The majority of these locations were excavated and removed during the 1999, 2000, and 2001 ISR work. Any remaining impacted soils will be evaluated in greater detail in the RA and FS.

Soil quality data, associated depths, and analytes for Area 5 are summarized in Table B.20-1 through B.20-9 in Appendix B. Figure 2.20-1 shows the sampling locations.

2.20.2 Area 8 Bunker C Pipeline and Former ASTs

The purpose of the interim action was to remove the former Bunker C pipeline and associated TPH-impacted soils along the pipeline and in the former aboveground storage tank (AST) area. The pipeline carried Bunker C fuel from the lower powerhouse and wharf area to the upper powerhouse. DERS removed TPH-impacted soils and the pipeline between January 1992 and August 1993. Approximately 29,100 cubic yards of soil and forty 55-gallon drums of residual product/cleaning waters were removed. The entire level portion of the pipeline and associated lead packing in the pipe joints were removed. The sloped section of the pipeline was cleaned and grout filled for abandonment in place.

Prior to source removal, 58 characterization soil samples were collected and analyzed for TPH. Selected samples were analyzed for PAHs, total lead, VOCs, and SVOCs. Following source removal, 48 verification soil samples were collected and analyzed for TPH. Selected samples were analyzed for PAHs. Forty-seven designation samples were collected from Area 8 stockpiles and analyzed for TPH prior to appropriate disposal.

With one exception, the ISR effectively removed all TPH soils where the concentration was above the Bunker C product-specific level of concern to a depth of 15 feet. The one exception is addressed in the FS and the remainder of Area 8 will not be addressed further.

ISR and verification sampling in Area 8 are discussed in Hart Crowser (1994b). An Ecology letter dated October 9, 1996, gave approval to backfill the excavations associated with the pipelines and aboveground Bunker C storage tanks in this area (Ecology 1996c).

Soil quality data, associated depths, and analytes for Area 8 are summarized in Table B.21-1 through B.21-6 in Appendix B. Figure 2.20-2 shows the sampling locations.

2.20.3 Area 18 Sympathetic Detonation

To minimize potential health and safety risks associated with potential explosive residuals within the former manufacturing foundations, an interim action involving sympathetic detonations was conducted where there had been historical use of NG.

Although the facilities in Area 18/1/2/3/4 were burned during site decommissioning, safety concerns were raised by the possibility that residual NG, TNT, or DNT might have permeated the remaining concrete foundations and adjacent soils. To reduce this potential hazard, an ISR was conducted involving a series of sympathetic detonations at selected foundations and along transport lines, primarily in the north and central part of the area—in the nitrators, neutralizers, and mixing houses.

Yenter Environmental Services and DERS conducted sympathetic detonations in 1992. The first phase of detonations was conducted at 15 foundations. The second phase was conducted in two additional foundations, various drainage ditches, and miscellaneous wash-down areas. Sympathetic detonations were repeated three times at each foundation's location following foundation removal.

At locations where residual explosives were suspected, detonations were set off. If residual explosive material was present in sufficient quantity, a secondary (sympathetic) explosion would result. As part of the ISR, foundation debris containing lead was sorted, removed, and appropriately disposed of; associated cover and berm soils were stockpiled. Where possible, lead debris was segregated and recycled. Following the sympathetic detonations, test pits were excavated at the foundations to characterize postdetonation soil quality, because many of the soils and fill materials evaluated during the pre-RI sampling were subsequently removed and/or stockpiled during these activities.

As part of the sympathetic detonation program, the concrete splash box next to the NG waste acid storage location in Unit 26B was detonated. The charge produced a second detonation, indicating that residual NG may have been present in the box. Secondary sympathetic detonations were not noted at other locations.

Following this work the soil berms, concrete walls, and timbers were demolished and removed. Soil excavated in association with the removal was stockpiled for designation and appropriate disposal. Following excavation of foundations, characterization soil samples were collected and incorporated into the RI database. Soil samples were analyzed for NAX, NG, and total metals.

Most of the elevated arsenic and lead concentrations remained after the initial ISR in Area 18 were remediated during the 1999, 2000, and 2001 ISRs. Any remaining impacted soils will be evaluated in greater detail in the RA and FS.

Sympathetic detonation activities and verification sampling in Areas 18 are discussed in Hart Crowser (1993b).

2.20.4 Area 19 Maintenance Areas

The purpose of the interim action was to remove paint and petroleum-stained soils at the former Paint Shop (19A) and Oil House (19B). DERS removed TPH- and lead-impacted soils and inorganic solid debris (ISD) between March and September 1992. Approximately 20 cubic yards of soil and 15 cubic yards of concrete and metal debris were removed from these areas.

For Area 19A, seven characterization, verification, and designation soil samples were collected and analyzed for PAH, TPH, VOCs, or total metals. For Area 19B 27 characterization, verification, and designation soil samples were collected and analyzed for PAH, TPH, VOCs, lead, or total metals.

ISR efforts effectively removed the majority of all constituents of concern to a depth of 15 feet. Any remaining impacted soils will be evaluated in detail in the RA and FS.

ISR and verification sampling in Areas 19A and 19B are discussed in Hart Crowser (1993c), in Area 19C in Hart Crowser (1993h).

Soil quality data, associated depths, and analytes for Area 19 are summarized in Table B.22-1 and B.22-2 in Appendix B. Figure 2.20-3 shows the sampling locations.

2.20.5 Area 20 Underground Storage Tanks

The ISR effectively removed all constituents on concern to a depth of 15 feet. Therefore, Area 20 will not be addressed further.

Removal, verification sampling, and closure of the Area 20 underground storage tanks (USTs) are documented in Hart Crowser (1991d). Additional removal of soil associated with an AST in Area 20B is documented in Hart Crowser (1993a). Ecology issued a letter specifying No Further Action (NFA) for Areas 20A and 20B (Ecology 1993a).

2.20.6 Area 24A Upper Power House

The Upper Power House was served by the Area 8 Bunker C Pipeline and used Bunker C fuel to power the entire former facility. The ISR in this area was conducted in several phases between 1989 and 1992. The purpose of the interim action was to demolish the Upper Power House including the powerhouse stack. Prior to demolition activities, characterization and lead abatement were conducted. Procedures were established for removal or containment of any remaining lead-paint-impacted material as part of demolition activities.

The 150-foot-high powerhouse stack was initially demolished by a U.S. Army special forces demolition team from Fort Lewis, Washington, on April 29, 1991. Between June 12 and June 18, 1991, CEcon Corporation completed the demolition and disposal of the generated material and associated ACM from the stack. The powerhouse was demolished during subsequent activities. All materials from these demolition activities were appropriately disposed of off Site following waste designation.

Removal of Bunker C TPH material from the Area 8 pipeline, which terminated in the powerhouse, was conducted in association with the Area 8 ISR. Pre-RI characterization in Area 24 identified TPH-impacted material in 4 of 5 hand-auger samples collected from the powerhouse floor sumps. Material from the sumps was removed along with other demolition material.

Soil quality data, associated depths, and analytes for Area 24A are summarized in Table B.21-1 through B.21-3 in Appendix B. Figure 2.20-4 shows sampling locations.

Analysis of the data indicated further action may be required after the ISR and, therefore, this area will be evaluated in greater detail in the RA and FS.

ISR and verification soil sampling in Area 24A are discussed in Hart Crowser (1991e and 1992h).

2.20.7 Area 30 Railroad Debris

The purpose of the interim action was to remove inorganic solid debris (ISD) containing lead in accordance with the Land Disposal Restrictions (LDRs) to decrease potential sources of lead to area soils. DERS removed ISD (approximately 80 cubic yards of soil and 60 cubic yards of timber debris) from Area 30 between March 26 and April 7, 1992. Less than 1 cubic yard of ISD lead was segregated from the excavated materials. Seven soil verification samples were collected and analyzed for lead, TPH, and 13 total metals. Three stockpile designation samples were also collected and analyzed following removal.

Analysis of the data indicated further action may be required after the ISR; therefore, this area will be evaluated in greater detail in the RA and FS.

ISR and verification soil sampling in Area 30 are discussed in Hart Crowser (1993d).

Soil quality data, associated depths, and analytes for Area 30 are summarized in Table B.24-1 in Appendix B. Figure 2.20-5 shows the sampling locations.

2.20.8 Area 31 Ravine Near Burning Ground

DERS removed debris from the ravine area between October 12 and 14, 1992. Approximately 400 cubic yards of soil and 60 cubic yards of debris were removed from the site, including five empty 55-gallon drums and one 55-gallon drum containing tar. Six verification/designation soil samples were collected and analyzed for NAX, arsenic, lead, mercury; one of these was analyzed for PAHs and TPH following removal. Five designation soil samples were collected from area stockpiles and analyzed for NAX, arsenic, lead, mercury, and TPH; three of these were analyzed for pesticides and PCBs, and PAHs.

Analysis of the data from the source removal action indicate that no further action is required in this area.

ISR and verification soil sampling in Area 31 Ravine are discussed in Hart Crowser (1993e).

2.20.9 Area 35 Tar Barrel Area

The ISR effectively removed all constituents of concern to a depth of 15 feet. Therefore, Area 35 will not be addressed further.

2.20.10 Area 36 Lead Melt House

The purpose of the interim action was to remove ISD containing lead in accordance with the LDRs to decrease potential sources of lead to area soils. DERS removed soil and debris at the Lead Melt House from March 25 to March 30, 1993. Approximately 6 cubic yards of soil and 5 cubic yards of debris were removed. Forty-nine soil characterization samples were collected and analyzed for total lead. Concentrations of total lead ranged from not detected to 120,000 mg/kg. Five samples were also analyzed for 13 metals. Four verification/designation soil samples were collected following removal.

Elevated arsenic and lead remained after the initial ISR. These locations were remediated further during the 1999, 2000, and 2001 ISRs. Any remaining impacted soils will be evaluated in greater detail in the RA and FS.

Antimony was detected in one of five samples at a marginally elevated concentration. However, because the antimony detection occurred in a sample with elevated lead and arsenic concentrations, antimony will not be addressed further.

ISR and verification soil sampling in Area 36 are discussed in Hart Crowser (1993f).

Soil quality data, associated depths, and analytes for Area 36 are summarized in Table B.23-1 in Appendix B. Figure 2.20-6 shows the sampling locations.

2.20.11 Area 38 Underground Storage Tank

During the RI soil sampling in Area 38, the fill spout for a UST was observed approximately 20 feet west of the drywell. The contents of the tank were sampled, and the tank was subsequently removed in accordance with Washington State UST regulations. No petroleum product or staining was observed within the tank excavation. Air monitoring (by an HNU photoionization detector [PID] and Draeger tube samples for benzene) indicated no evidence of VOCs. No petroleum compounds were detected in verification soil samples collected within the tank excavation, indicating that the tank did not leak. The UST sampling and removal activities for Area 38 are summarized in a UST Closure Report submitted to Ecology (Hart Crowser 1992f). Ecology issued a letter specifying NFA for the Area 38 UST (Ecology 1993b).

2.20.12 Area 39 Laboratory

The purpose of the interim action was to remove mercury-contaminated soils. DERS removed soils with mercury at the Former Laboratory from March 2 to August 14, 1992. A sump, drainline, UST, and 85 feet of piping were removed. Approximately 1,600 cubic yards of soil were excavated and disposed of off Site. Seventy-six soil characterization samples were collected and analyzed for VOCs, SVOCs, and metals. Five samples were analyzed for mercury speciation by the Battelle Marine Sciences Laboratory. Thirty-four verification soil samples were collected following excavation.

Elevated arsenic, lead, and mercury were detected in one or more samples following ISR in Area 39; therefore, the area will be evaluated in greater detail in the RA and FS.

ISR and verification soil sampling in Area 39 are discussed in Hart Crowser (1993g). Removal, verification sampling, and closure of the UST in Area 39 are documented in Hart Crowser (1992g). On May 6, 1993, Ecology issued a letter specifying NFA for the Area 39 UST (Ecology 1993c).

Soil quality data, associated depths, and analytes for Area 39 are summarized in Table B.26-1 through B.26-6 in Appendix B. Figure 2.20-7 shows the sampling locations.

2.20.13 Lead-Contaminated Debris Removal—Areas 18S, 19C, and 31

The purpose of the interim action was to remove ISD containing lead in accordance with the LDRs to decrease potential sources of lead to area soils. These areas were identified for removal based on visual observations of ISD lead. DERS removed visible ISD lead and soil from Areas 18S (Powderline Area Gelatin Cartridge House No. 3), 19C (Lead Shop), and 31 (Burning Ground) during the first phase of removal in May 1992. The extent of lead debris (not lead concentrations) formed the basis for source removal excavation limits. In July 1993, a second

phase of work removed DNT-impacted soils in Area 31. This was a removal action separate from the one described in Section 2.20.14. Approximately 115 cubic yards of soil and 45 cubic yards of debris were removed from Area 18S. Approximately 55 cubic yards of soil and 25 cubic yards of debris were removed from Area 19C. Approximately 70 cubic yards of ISD lead and associated soil, 40 cubic yards of DNT-impacted soil and 35 cubic yards of debris were removed from Area 31.

Following ISR, 3, 5, and 11 verification soil samples were collected from Areas 18S, 19C, and 31, respectively. Samples from Area 18S were analyzed for total metals, TPH, NAX, and NG. Samples from Area 19C were analyzed for metals. Samples from Area 31 were analyzed for total metals, NAX, and TPH (one sample).

Elevated concentrations of lead remained in soil in Areas 18S, 19C, and 31 after the initial ISR. These areas were remediated further during 1999, 2000, and 2001 ISRs. Any remaining impacted soils will be evaluated in greater detail in the RA and FS. ISR and verification soil sampling for ISD lead in these areas are discussed in Hart Crowser (1993h).

2.20.14 DNT Soil Removal—Areas 10, 18, 25, and 31

The purpose of the interim action was to remove DNT-impacted soil to decrease potential sources of DNT to site groundwater. DERS removed approximately 37,500 cubic yards of DNT-impacted soil from Areas 10, 18, 25, and 31 in February and October 1993.

Following ISR in Area 10, eight verification soil samples (10-VS-1 through 10-VS-8) were collected from the bottom and along the excavation sidewalls. Surficial soil at locations 10-VS-3 and 10-VS-5 was later excavated during subsequent ISR.

In Area 18, residual DNT/TNT-containing soils were excavated in the vicinity of the five foundations. During the excavation at Gelatin Mixing House No. 1, a 4-inch-diameter ceramic/iron pipe filled with DNT/TNT residual was observed. The pipe discharged to the southeast of the mixing house foundation, where crystalline residual was observed. The residual DNT/TNT at the pipe discharge location—approximately 75 by 50 feet and up to 6 inches thick—was carefully excavated as part of the ISR. To address the potential for similar discharge pipes associated with other foundations, a series of continuous trenches was excavated on all four sides of all dynamite and gelatin mixing houses, at distances of 25 to 100 feet from the foundations. No additional discharge lines were observed during the trenching at any of the mix houses.

Following ISR, 6, 173, 16, and 7 verification soil samples were collected from Areas 10, 18, 25, and 31, respectively. All samples were analyzed for NAX. In Area 18, 17 samples were analyzed for total lead, and 2 samples were analyzed for four metals (arsenic cadmium, lead, and mercury). Four samples in Area 25 and all seven samples in Area 31 were analyzed for total lead.

ISR successfully removed soil containing DNT above the ISR excavation target level of 1 mg/kg, and any associated TNT. Analytical results for the verification soil samples indicate that DNT concentrations in the remaining soils were not elevated, with the exception of 5 locations in Areas 18 and 25 locations at a depth greater than 15 feet. One soil sampling location in Area 10 contained an elevated TNT concentration. This location was remediated during 1999, 2000, and 2001 ISRs.

ISR for DNT-impacted soil and verification soil sampling in these areas are discussed in Hart Crowser (1994a).

Elevated concentrations of lead remained in these areas after ISR. These locations were remediated during 1999, 2000, and 2001 ISRs. Any remaining impacted soils will be evaluated in greater detail in the RA and FS.

2.20.15 Lead and Arsenic Hot Spots

Areas with high arsenic and lead concentrations (referred to as “hot spots”) were identified during site characterization. Most of the high arsenic locations were along the NGRR track (refer to Sections 2.16 and 2.18), while most of the high lead concentrations were near specific building foundations (refer to Section 2.16).

The two tasks of the hot spot removal program were as follows:

- Remove hot spots in site areas south of Sequalitchew Creek that exceed placement area remediation levels.
- Remove hot spots and other affected soils in the industrial area north of Sequalitchew Creek in order to achieve industrial cleanup levels.

Active Construction (ACTIVE) removed approximately 18,500 cubic yards of soil between September 10, 1999, and July 24, 2000, as part of this interim action. The lead and arsenic hot spot soils were excavated and stockpiled for future treatment and disposal, which was completed in 2001. Soils containing TNT were stockpiled separately and disposed of off Site.

Following hot spot removal, elevated concentrations of lead and arsenic remained. The majority of these locations were remediated during 2001 ISR. Any remaining impacted soils will be evaluated in greater detail in the RA and FS.

Hot spot removals included Areas 10, 31, NGRR, and RR-546. The hot spot excavation in Area 10 was expanded to remove one elevated TNT sample. Since the hot spot removal in these areas, no further action is required.

No hot spot excavations were conducted in open space areas or in areas within or immediately adjacent to known historical sites. These and any other elevated concentration sampling locations within open space or historical areas will be addressed in the RA and FS.

ISR and verification soil sampling in the hot spot areas are discussed in the Hot Spot Interim Action Report (West Shore et al. 2000a).

2.20.16 Foundation, NGRR, Hot Spot, and Top Soil Laydown Area

This interim action resulted in the following soil excavations:

- 2 to 8 feet deep in a 50- by 50-foot area around selected building foundations
- 1.5 to 2.5 feet deep 25 feet on either side of the narrow-gauge track centerline along the selected lengths of NGRR
- 1.5 to 3 feet deep in areas up to 50 by 50 feet around hot spot areas that may require on-Site screening and/or off-Site disposal

- Arsenic and lead areas (Sequalitchew Creek NGR, Area 38, and location R71C85)
- NAX locations in Areas 10 and 18
- 1.5 to 2.5 feet deep in two topsoil laydown areas

ACTIVE removed a total of 158,160 cubic yards of soil between June 4 and September 21, 2001, as part of this interim action. A total of 699 verification samples were collected and analyzed for arsenic, lead, DNT, and TNT. An additional seven characterization samples were collected from remaining hot spot locations and analyzed for arsenic, lead, DNT, and TNT. Based on the

evaluation of sampling data, no elevated concentrations of lead, arsenic, DNT, or TNT remain except for the following:

- Seven locations for arsenic (all in Sequalitchew Creek NGRR)
- Fourteen locations for lead

Further remediation of these locations will be addressed in the FS.

ISR and verification soil sampling in the miscellaneous areas are discussed in the Interim Corrective Action Report (West Shore et al. 2001).

2.20.17 Sand Laydown Areas

The objective of this interim action was to remove surface soil from six areas on the Site so that sand could be stockpiled in these areas and not moved again until final Site remediation. Between 1.5 and 3 feet were removed from each of the six areas in 2000. Verification soil samples were collected within each SLA excavation and analyzed for arsenic and lead.

The results indicated the following:

- In general, postexcavation sample concentrations were near or below background levels for both lead and arsenic. Exceptions were samples with elevated lead concentrations associated with visible debris or foundations.
- No sand was stockpiled in SLA areas where there were visible debris (SLA 1) or foundations (SLA 1, SLA 6).
- With the exception of the debris- and foundation-associated samples, all six SLA areas require no further action.

ISR and verification soil sampling in the miscellaneous areas are discussed in the Sand Laydown Area Interim Action (West Shore et al. 2000b). Figure 2.20-8 shows the sampling locations.

This section presents the findings of the RI groundwater characterization efforts at the Site. Sections 3.1 and 3.2 present specific information on the physical groundwater system and groundwater quality. Appendices A and C present field procedures and tables on groundwater quality, respectively.

3.1 HYDROGEOLOGIC CHARACTERIZATION

3.1.1 Site Geology

The interpretation of the Site geologic and hydrogeologic conditions has been developed from Hart Crowser's work on the Site and from explorations conducted north of the Site by others. The locations of monitoring wells, staff gauges, and geophysical surveys completed by Hart Crowser and used for interpretation of Site hydrogeologic conditions are shown in Figure 3.1-1.

Three major stratigraphic units were encountered during explorations at the Site, the Vashon Drift (which includes the Steilacoom Gravel), the Olympia Beds/Possession Drift/Whidbey Formation/Double Bluff Drift sequence (hereafter referred to as the DBD-OB sequence), and the Salmon Springs Glaciation. Locations of monitoring wells and cross sections are shown in Figure 3.1-1. Generalized subsurface cross sections are shown in Figures 3.1-2 and 3.1-3.

Vashon Drift

The Vashon Drift is composed of the following units, from the surface down (youngest to oldest):

- Steilacoom Gravel
- Vashon Till (observed at only a few locations on the Site)
- Vashon Advance Outwash (comprising Advance Gravel overlying Advance Sand)

Steilacoom Gravel

The Steilacoom Gravel unit of the Vashon Drift was encountered in all of the borings completed at the Site. The Steilacoom Gravel was deposited by high-energy meltwater rivers that flowed generally toward the west from a dammed proglacial lake located in the Puyallup River valley during retreat of the final (Vashon) glaciation (Walters and Kimmel 1968). The Steilacoom Gravel was deposited within the extensive outwash channels carved by the meltwater rivers that covered much of the Tacoma uplands west of the Puyallup River. The rivers discharged their vast quantities of bedload into a pro-glacial lake in the approximate location of Puget Sound, forming the ancestral Sequelitchew and Steilacoom Deltas. The Site is situated on the southern margin of the ancestral Sequelitchew Delta. The ancestral Steilacoom Delta occurs in the Steilacoom/Chambers Creek area several miles to the north.

The thickness of the Steilacoom Gravel unit typically ranges between 20 and 40 feet over much of the eastern portion of the Site. In this portion of the Site, additional gravelly soils (Vashon Advance Outwash Gravels) exist beneath the Steilacoom Gravel, as discussed below. In the western portion of the Site, the Sequelitchew Delta deposits are present. In these deposits, the Steilacoom Gravel has been encountered during explorations to a depth of approximately 220 feet in on-site monitoring well borings (e.g., MW-1). Regional information from a deep

test/production well completed north of the Site indicates that the deltaic Steilacoom Gravel deposits are approximately 330 feet thick, extending to an approximate elevation –120 feet msl.

The Steilacoom Gravel is described as medium dense to very dense, well-graded, light brown and gray, stratified sands and gravels. Generally, the deposits are exceptionally coarse-grained, with localized zones of silty to slightly silty sand. What has been described as Steilacoom Gravel across the Site may also include the Vashon Recessional Gravel unit; similar gravelly materials were deposited during retreat of the Vashon glaciation but prior to the deposition of the Steilacoom Gravel, which is associated specifically with the break of the glacial ice dam to the east. However, it is likely that most of the Recessional Gravel was eroded during deposition of the Steilacoom Gravel, as discussed below.

Vashon Till

Material interpreted to be Vashon Till was encountered in the borings for MW-27 and MW-22 located in the west-central portion of the Site (Figure 3.1-1). The till was described as very dense, gray-brown, silty-gravelly sand, which occurred between depths of approximately 37 and 48 feet in the two monitoring well borings. The till has been tentatively identified in at least one other soil boring on the Site (11-B-501), located approximately 1,200 feet southwest of wells MW-22 and MW-27. The high density and higher silt content of the till makes it a weak aquitard upon which perched water has been observed. The discontinuity of the Vashon Till across the Site suggests that it was eroded during the high-energy scouring and deposition of the Steilacoom Gravel, leaving only isolated deposits. If the Vashon Till was eroded during the deposition of the Steilacoom Gravel, the overlying Vashon Recessional Gravel would have been eroded also.

Vashon Advance Outwash

The Advance Outwash was deposited by glacial rivers or streams during advance of the Vashon glaciation. The Advance Outwash can be divided into Advance Gravel and the underlying Esperance Sand (formerly known as Advance Sand). This sequence of soil types (becoming finer-grained with depth) is typical of advance outwash deposition.

The Advance Gravel unit of the Vashon Drift occurs beneath the Steilacoom Gravel and is difficult to differentiate from the overlying Steilacoom Gravel. The deposits are described as light brown to gray, slightly silty to non-silty, stratified sands and gravels; however, the Advance Gravels are generally not as coarse-grained as the overlying Steilacoom Gravel.

The Esperance Sand unit was observed beneath the Advance Gravel in some borings and consists of dense, slightly gravelly to gravelly, non-silty to silty, coarse to fine sand. Silty, fine sand encountered in MW-20 and MW-21 appears to represent the lower portion of the Esperance Sand, and the bottom of the Advance Outwash sequence; however, this material may also represent a sandier facies within the DBD-OB sequence (Borden and Troost, 2001).

Olympia Beds/Possession Drift/Whidbey Formation/Double Bluff Drift Sequence

Generally, the DBD-OB sequence is a fine-grained, regionally extensive, interglacial deposit, which separates the glacial deposits of the Vashon Drift and Salmon Springs Glaciation. Five on-site borings were drilled to the top of the DBD-OB sequence, and one of these (MW-18) was

drilled through the formation to the underlying Sea Level Aquifer within the Salmon Springs Glaciation. The DBD-OB sequence has a variable composition of interbedded sand and silts, typical of interglacial deposits. Materials observed in the DBD-OB sequence include stiff to hard, brown, gray, and black silt, sandy silt, and peat, interbedded with silty sand.

Drilling information from Fort Lewis (located north of the Site) confirms that the DBD-OB sequence is a thick (ranging from approximately 70 to 100 feet), very heterogeneous formation generally consisting of a thick organic silt and peat unit with abundant interbedded sand and gravel layers (Woodward-Clyde 1990). Other regional data, including drilling of the Bell Hill water supply wells east of the Site (Hart Crowser 1988b; Hart Crowser 1990), confirm the general character and thickness of the DBD-OB sequence and indicate that the unit is regionally continuous.

Data from the RI drilling program support the general electromagnetic (EM) geophysical interpretation that the top of the DBD-OB sequence has significant structural relief (Hart Crowser 1992c). The topographic relief of the upper surface of the DBD-OB sequence (defined as the first occurrence—upper contact—of stiff silt) may be the result of differences in the deposition of the interglacial sediments comprising the DBD-OB sequence, and/or subsequent scouring of the surface during glacial deposition of the overlying Vashon Outwash.

The geophysical data suggest that the DBD-OB sequence occurs at higher elevations, forming a structural bench in the west-central part of the Site beneath part of Area 18. The drilling data generally confirm this interpretation. The top of the DBD-OB sequence was encountered at an elevation of approximately 130 feet in MW-18, located within Area 18 (Figure 3.1-1), which is higher than in any other boring on the Site. The DBD-OB sequence was observed at elevations ranging from approximately 70 to 110 feet in the four other borings in which it was encountered on the Site (MW-11, MW-17, MW-20, and MW-22). MW-18, which was advanced through the DBD-OB sequence, defined the bottom of the formation at an elevation of 55 feet (formation thickness of approximately 75 feet).

Olympia Beds/Possession Drift/Whidbey Formation/Double Bluff Drift Sequence “Cutoff”

The DBD-OB sequence is not present west of a line located up to 2,500 feet inland from Puget Sound and oriented roughly parallel to the shoreline in this region. The line representing the western extent of the formation has been informally termed the “Cutoff” (formerly known as the Kitsap Cutoff) for this study. Data from numerous soil borings and several EM geophysical survey lines were compiled to infer the location of the “Cutoff” across the Site, as shown in Figure 3.1-1. The thickness of the DBD-OB sequence appears to decrease at its western margin due to erosion during the deposition of the Vashon Outwash and/or Steilacoom Gravel (Figure 3.1-2).

A potential paleochannel within the DBD-OB sequence may have been encountered during the drilling of MW-21 in the central portion of the Site (Figure 3.1-1). The boring was advanced through silty sand to an elevation of 50 feet msl without encountering a competent silt unit, which is generally indicative of the DBD-OB sequence. A thin silt layer was indicated based on drill action at a depth of 125 feet, but no sample was retrieved due to the heaving conditions (borehole collapsing). Although this apparent silt lens occurred at an elevation of approximately 90 feet msl and is in the range of DBD-OB sequence elevations observed elsewhere on the Site, it does not appear to be a remnant of the DBD-OB sequence because the silty sands above and

below it were essentially identical. The sand became finer-grained and more silty with depth, which is typical of Advance Outwash deposition.

These drilling observations also support the general interpretation of the geophysical survey data, which suggest that such a paleochannel may have been eroded into the DBD-OB sequence in this general vicinity (see Figure 4 in Hart Crowser 1992c). As a result of these observations, the inferred trace of the “Cutoff” has been extended to the east of MW-21 (as shown in Figure 3.1-1). The potential paleochannel is discussed below in relation to the Water Table Aquifer.

Salmon Springs Glaciation

The Salmon Springs Glaciation (formerly known as the Salmon Springs Formation) was deposited in the glacial period preceding the DBD-OB sequence interglacial. The formation is relatively heterogeneous and consists of dense, brown, fine sand, and dense, brown, gravelly sand with gravel interbeds. The top of the formation was encountered at a depth of 163 feet (elevation 55 feet msl) in MW-18. Regional information indicates that the formation is on the order of 70 to 120 feet thick and contains zones of organic silt and till in some locations, possibly suggesting deposition in two glacial periods separated by a minor interglacial event (Noble 1990). The Sea Level Aquifer, a regionally extensive aquifer, occurs within the Salmon Springs Glaciation. Some authors refer to this aquifer as the Flett Creek Unit (Noble 1990).

3.1.2 Site Hydrogeology

The hydrogeologic system beneath the Site includes two aquifers: the shallow unconfined aquifer (Water Table Aquifer) in the Vashon Drift sediments, and the deeper Sea Level Aquifer in the Salmon Springs and (west of the “Cutoff”) Steilacoom Gravel sediments. In addition, seasonally perched groundwater was encountered at the Site, as discussed below.

The Sea Level Aquifer occurs locally in the immediate Site area under both semiconfined and unconfined conditions (as discussed below). Regionally, however, this aquifer occurs under confined conditions to the east of the Site. The DBD-OB sequence acts as an aquitard (Aquitard) separating the aquifers. Along the western portion of the Site, to the west of the “Cutoff”, a single aquifer (unconfined portion of the Sea Level Aquifer) is present.

Perched Groundwater

A zone of perched groundwater was encountered at a depth of approximately 40 feet during February 1992 drilling of monitoring wells MW-22 and MW-27. These wells are located within 50 feet of each other in the western portion of the Site (Figure 3.1-1). Well MW-27 was installed for monitoring and sampling of the perched groundwater.

The groundwater appears to be perched on an 8- to 10-foot-thick lens of till-like material, which may be Vashon Till. The till-like material was also observed during drilling soil boring 11-B-501, located approximately 1,200 feet southwest of the two wells. Monitoring suggests that this perched water is transient, disappearing during the dry summer and autumn months. Approximately 6 inches of water remained in MW-27 during the June 1992 water sampling round. The well then remained dry until the December 1992 sampling round, when it again contained less than 1 foot of water. Continued monitoring through 1993 confirmed the

disappearance of the perched water in late summer and autumn. During sampling, the well always bailed dry and recovered exceedingly slowly, indicating that the silty till material is of relatively low permeability and that the zone of saturation is limited.

Possible perched groundwater was encountered between depths of approximately 20 and 35 feet in the deep RI soil boring (7-B-503) completed within the bottom of the Area 7 kettle. No competent silt unit was encountered in this boring to act as a significant perching unit. A well (7-B-503) was completed within the zone of saturation. Similar to well MW-27, this well bailed dry during sampling and subsequent water level recovery was extremely slow, suggesting that the perched water may be discontinuous. However, unlike at MW-27, the 7-B-503 monitoring well has been dry since its initial sampling in July 1992. Other borings completed within the bottoms of the kettles encountered some zones of saturation (discussed in Sections 2.5, 2.9, and 2.12), but they were discontinuous within borings (vertically) and laterally between borings within each kettle. These observed zones may have been infiltrating wetting fronts rather than perched zones of groundwater. Monitoring well 7-B-503 and the (dry) monitoring wells installed in the Area 16 and 26 kettles (16-B-501 and 26-B-503, respectively) are shown in Figure 3.1-1.

Water Table Aquifer

The Water Table Aquifer occurs within the saturated portion of the Vashon Glacial Drift (both Steilacoom Gravel and Advance Outwash) and receives recharge from infiltration of precipitation through permeable overlying soils. The water table in this aquifer is encountered at depths ranging from approximately 20 to 30 feet below ground (elevations of 190 to 200 feet msl) in the eastern portion of the Site up to approximately 110 to 120 feet below ground (elevations of 90 to 110 feet) near its western extent at the “Cutoff”.

Groundwater in the Water Table Aquifer generally flows to the west-northwest, toward Puget Sound. At the “Cutoff”, the Water Table Aquifer discharges into the Steilacoom Gravel. As shown schematically in Figure 3.1-2, groundwater from the Water Table Aquifer flows over the edge of the Aquitard and mixes with groundwater flowing in the unconfined portion of the Sea Level Aquifer. Figures 3.1-4, 3.1-5, and 3.1-6 are elevation contour maps (April, August, and December 1992, respectively) for the water table surface in both the Water Table Aquifer and the Sea Level Aquifer west of the “Cutoff” (i.e., a map of the continuous water table surface across the two aquifers). These monitoring rounds include the most comprehensive set of water level measurements. The figures demonstrate the very steep water table gradient present along the “Cutoff”. This hydrogeologic situation has also been documented to the north of the Site (Woodward-Clyde 1990).

In the vicinity of Sequelitchew Creek on the Site, the Water Table Aquifer discharges into the creek (Figures 3.1-4, 3.1-5, and 3.1-6) and reaches Puget Sound as surface water. The water table elevation contour maps suggest a subtle groundwater divide, or area in which groundwater flows horizontally in more than one direction, from Old Fort Lake west to the “Cutoff”. The higher groundwater elevation near Old Fort Lake (the lake level is an expression of the water table) may indicate recharge to the aquifer from the lake. The divide appears to extend west of the lake, with resulting groundwater flow to the northwest and to the west-southwest (Figures 3.1-4, 3.1-5, and 3.1-6). The presence of the groundwater divide may also suggest a possible

structural high on the Aquitard surface in this area, as discussed in Section 3.1.1 (higher groundwater elevation because of a higher underlying aquitard surface).

Water table elevation data from monitoring wells near Area 31 north of Sequalitchew Creek (MW-7, MW-8, MW-9, and MW-24) and creek elevation data from adjacent staff gauge SG-4 indicate a groundwater divide in this area. From the center of the divide, the water table slopes steeply toward the creek (south), resulting in groundwater flow toward Sequalitchew Creek.

Further to the north, groundwater flows almost parallel to the creek (Figures 3.1-4, 3.1-5, and 3.1-6). Regional information indicates groundwater flows toward the west-northwest in the Water Table Aquifer north of the Site (Woodward-Clyde 1990).

Seasonally, there is little change in the groundwater flow directions in the Water Table Aquifer, as indicated by the groundwater flow direction maps presented in Figure 3.1-4 (April 1992), Figure 3.1-5 (August 1992), and Figure 3.1-6 (December 1992). The water table generally responds uniformly to seasonal precipitation changes, resulting in little change in the directional flow of groundwater. The data do indicate a slightly higher gradient in the Water Table Aquifer beneath Area 31 (immediately north of Sequalitchew Creek) toward the creek during the wetter spring months. The creek elevation at staff gauge SG-4 remained essentially constant while the water table elevations around it fell from the wet (April) to dry (August through December) seasons, resulting in a lower gradient toward the creek in the dry season (Figures 3.1-4, 3.1-5, and 3.1-6). Seasonal changes in surface water elevations are discussed in Section 3.1.3.

Figure 3.1-7 presents hydrographs for selected Water Table Aquifer monitoring wells over a 4-year period of monitoring (1988 through 1992). The hydrographs indicate that the aquifer responds fairly uniformly to seasonal changes, with fluctuations on the order of 3 to 8 feet. No long-term trends are apparent from the data (e.g., long-term decline due to drought).

The thick silt unit typically associated with the Aquitard was not encountered to an elevation of approximately 50 feet msl during drilling of MW-21. Very silty to silty, fine sand was encountered in the elevation range (approximately 50 to 100 feet msl) where hard silt and some peat was encountered in other on-site borings (e.g., MW-18, MW-20, and MW-22). This finding suggests a possible paleochannel incised within the DBD-OB sequence in this general location, as discussed above. Figure 3.1-3 presents the interpretation of subsurface conditions from south to north across this potential paleochannel. The profile location is shown in Figure 3.1-1.

The silty, fine sand is interpreted to represent the lower portion of the Vashon Advance Outwash rather than a sandy facies within the DBD-OB sequence. Although the depositional origin of these materials may vary, the water table elevation in MW-21 is consistent with measured elevations in other wells in the vicinity, indicating that the silty sand supports the Water Table Aquifer above it. Because a thick competent silt unit does not appear to be present within this potential paleochannel, downward flow of groundwater from the Water Table Aquifer may be greater in this area than elsewhere across the Site where the silt is present. However, the water level data do not indicate preferential flow toward the paleochannel; that is, the data do not indicate that the area is a significant groundwater sink (Figures 3.1-4, 3.1-5, and 3.1-6).

Aquitard

Across most of the Site, a low-permeability unit within the DBD-OB sequence (Aquitard) hydraulically separates the Water Table Aquifer from the underlying Sea Level Aquifer. The

“Cutoff”, as discussed above, represents the western extent of the Aquitard. This line is also the western extent of the Water Table Aquifer and is where the Sea Level Aquifer changes from semiconfined conditions (beneath the Aquitard to the east) to unconfined conditions (to the west).

As discussed in Section 3.1.1, site-specific and regional information indicate that the Aquitard acts as a regionally extensive low permeability unit within the DBD-OB sequence between the Water Table and Sea Level Aquifers. A difference in hydraulic head (water table elevation) of greater than 100 feet is observed in on-Site wells completed above and below the aquitard unit (e.g., MW-22 and MW-18, respectively).

Sea Level Aquifer

The Sea Level Aquifer is divided into two distinct portions: the portion occurring east of the “Cutoff” and the portion west of it.

East (upgradient) of the “Cutoff”, the Sea Level Aquifer occurs within permeable deposits of the Salmon Springs Glaciation, which are encountered immediately below the Aquitard at depths of 150 to 170 feet below ground. Regionally confined conditions exist within this portion of the aquifer (Hart Crowser 1988b; Hart Crowser 1990; Woodward-Clyde 1990). Near the “Cutoff”, the artesian pressure dissipates and the Sea Level Aquifer becomes unconfined (water table conditions exist [e.g. MW-18]). Therefore, the Sea Level Aquifer east of the “Cutoff” is referred to as a semiconfined aquifer.

West (downgradient) of the “Cutoff”, the unconfined Sea Level Aquifer occurs within the saturated portion of the thick deltaic sequence of the Steilacoom Gravel. Although the Steilacoom Gravel is the youngest unit within the Vashon Drift, it is differentiated hydrostratigraphically because of its unique (coarse-grained and highly permeable) lithology and its hydrogeologic significance within the Site. The water table within the unconfined Sea Level Aquifer is encountered at depths of 160 to 200 or more feet below ground (elevations from approximately 40 feet to less than 5 feet msl).

The Steilacoom Gravel is in direct contact with Vashon Drift, the Aquitard, and the Salmon Springs Glaciation (as shown in Figure 3.1-2). Therefore, the unconfined Sea Level Aquifer receives discharge from both the Water Table Aquifer and the semiconfined Sea Level Aquifer east of the “Cutoff”. Water from the two aquifers mixes within the unconfined Sea Level Aquifer (Steilacoom Gravel) and discharges toward the west. The unconfined Sea Level Aquifer discharges to Puget Sound as seeps observed along the shore (such as SEEP 1 and SEEP 2 in Figure 3.1-1) and presumably beneath sea level, where the deltaic deposits terminate in Puget Sound.

Groundwater and surface water elevation data collected during the RI suggest that the lower reach of Sequatchew Creek loses water to the unconfined Sea Level Aquifer. This is consistent with the high infiltration capacity of the gravels observed at the base of the drainage. As shown in Figure 3.1-4, the April 1992 creek elevation at SG-1 is at least 4 feet higher than water table elevations in either of the nearest wells completed in the unconfined Sea Level Aquifer (MW-1 and MW-15), indicating flow from the creek to the aquifer. No springs have been observed along the creek anywhere within this relatively flat stretch of creek valley. The creek was dry at SG-1 from August 1992 through January 1993, indicating that, at low summer/autumn creek

flows, all creek flow discharges to the unconfined Sea Level Aquifer. In the vicinity of SG-2 farther up the creek, the groundwater and surface water elevation data are less conclusive, but it appears that the creek is also losing to the aquifer in this area. The water level data indicate that, in general, the creek is gaining (receiving recharge) from the Water Table Aquifer east of the ‘Cutoff’ (upper portion of the drainage).

The Sea Level Aquifer east of the “Cutoff” receives recharge principally from infiltration of precipitation in areas east of the Site. The Sea Level Aquifer west of the “Cutoff” receives additional recharge from groundwater flowing from the Water Table Aquifer and semiconfined portion of the Sea Level Aquifer, as well as from infiltration of precipitation through the overlying unsaturated Steilacoom Gravel.

Figure 3.1-8 presents hydrographs for selected Sea Level Aquifer monitoring wells for the period 1988 through 1992. As with the Water Table Aquifer, the hydrographs indicate that the water table in the Sea Level Aquifer responds fairly uniformly to seasonal changes, particularly near Puget Sound. Nearer the “Cutoff”, there is greater difference in the responses between wells (e.g., MW-4 and MW-6), which is not unexpected considering the nature of the water table surface as it crosses the “Cutoff”. Water table elevation fluctuations in the Sea Level Aquifer are only 2 to 3 feet less than the 3- to 8-foot fluctuations observed in the Water Table Aquifer. No long-term water level trends are apparent for the Sea Level Aquifer.

Because the Sea Level Aquifer is in hydraulic connection with Puget Sound, a natural saltwater/freshwater mixing zone is present along the western margin of the aquifer. Over the period of monitoring, total dissolved solids (TDS) ranged from approximately 10,000 to 16,000 mg/L in SEEP 1 and SEEP 2, which discharge from the Sea Level Aquifer (Figure 3.1-1). These elevated TDS values are indicative of discharge from the saline mixing zone. The TDS values for Sea Level Aquifer monitoring wells MW-16 and MW-19, located within approximately 400 feet of Puget Sound, are generally less than 200 mg/L, which is similar to values from the other on-Site monitoring wells located farther inland. These data indicate that the mixing zone is not extensive, extending inland less than 400 feet.

Hydraulic Conductivity Testing of Aquifers

Data from two in situ testing methods (variable-head tests [i.e., slug tests] and short-term pumping tests) and laboratory grain size analyses of aquifer materials were evaluated to provide estimates of saturated hydraulic conductivity for the Water Table and Sea Level Aquifers. The short-term pumping tests were conducted in on-Site monitoring wells using a 2-inch submersible pump. In addition, hydraulic conductivity estimates from regional hydrologic reports were used to further refine a reasonable range of hydraulic conductivity values for the aquifers. Hydraulic conductivity estimates from Site-specific and regional data for the three aquifers (Water Table, unconfined Sea Level, and semiconfined Sea Level Aquifers) are summarized in Table 3.1-1.

Table 3.1-2 provides the hydraulic conductivity values estimated by application of the Kozeny-Carmen equation (Freeze and Cherry 1979) to grain size data for samples of aquifer materials. The analyses assumed a range of porosity values of 0.20 to 0.35, which is reasonable for the range of aquifer materials at the Site.

Water Table Aquifer

Site-specific hydraulic conductivity (K) estimates for the Water Table Aquifer ranged from 2×10^{-3} to 7×10^{-2} cm/sec and were derived from five slug tests and two short-term pumping tests conducted in on Site monitoring wells as part of the RI (Table 3.1-1). The geometric means of six estimates from the Kozeny-Carmen equation (Freeze and Cherry 1979) were 5×10^{-1} and 4 cm/sec, corresponding to assumed porosities of 0.20 and 0.35, respectively (Table 3.1-2).

Regional estimates of Water Table Aquifer hydraulic conductivities range from 4×10^{-3} to 2×10^{-2} cm/sec, based on pumping test results from City of DuPont Well No. 1 (Associated Earth Sciences 1984) and test well PW-1A at Fort Lewis (Woodward-Clyde 1990).

The range of hydraulic conductivity values is reasonable considering the different lithologies comprising the Water Table Aquifer—highly permeable Steilacoom Gravels to fine sand in the lower horizons of the Advance Outwash. Because of the slope of the water table and the general fining-downward (decrease in grain size with depth) sequence of the aquifer materials, the average hydraulic conductivity of the Water Table Aquifer may decrease somewhat from the east (saturated Steilacoom Gravel) to the west (saturated Advance Outwash deposits) across the Site. Although the data are variable, the hydraulic conductivity estimate from MW-22 near the “Cutoff” are somewhat lower than estimates from wells to the east (e.g., MW-7 and MW-12), lending some support to this hypothesis. However, different testing methods (e.g., short-term pumping tests versus slug tests) may also contribute to the differences in the estimates.

The available data presented in Table 3.1-1 suggest that a reasonable range of hydraulic conductivities for the Water Table Aquifer is 5×10^{-3} to 5×10^{-2} cm/sec. This range is referred to in Table 3.1-1 as the Best Estimate Range.

Semiconfined Sea Level Aquifer (East of Kitsap Cutoff)

Reported values of hydraulic conductivity (K) for the Sea Level Aquifer east of the “Cutoff” are in the range of 6×10^{-3} to 5×10^{-2} cm/sec, based on results from two pumping tests performed in Bell Hill Well No. 1 (Hart Crowser 1988b; Hart Crowser 1990), and pumping tests conducted in Weyerhaeuser Well No. 3 and Fort Lewis Well No. 18 (Associated Earth Sciences 1984). A slug test performed in monitoring well MW-18 produced an estimated K of 4×10^{-3} cm/sec, which is lower than the values from the pumping tests.

These results suggest that a reasonable range of hydraulic conductivities for the semiconfined Sea Level Aquifer is from 1×10^{-2} to 5×10^{-2} cm/sec (Table 3.1-1).

Unconfined Sea Level Aquifer (West of “Cutoff”)

Slug tests conducted in monitoring wells completed in the unconfined Sea Level Aquifer produce K estimates ranging between 2×10^{-3} to 2×10^{-2} cm/sec. The slug test results may be biased low due to the influence of the wellbore sandpack materials, which may actually have lower in situ permeability than the native (undisturbed) aquifer materials. Hydraulic conductivity estimates from grain size data of the Steilacoom Gravel aquifer materials range from 2×10^{-2} to 1 cm/sec (Table 3.1-2). Woodward-Clyde (1990) reported a range of hydraulic conductivities for the unconfined Sea Level Aquifer of 4×10^{-1} to 4 cm/sec, based on literature values.

It should be noted that based on available information, pumping tests have not been conducted within the unconfined Sea Level Aquifer (west of “Cutoff”) in the region. As a result, hydraulic conductivity estimates for this aquifer are developed from the slug tests and grain size data, and from regional studies also evaluating grain size characteristics. On the basis of these data and the uncertainty associated with them, a reasonable hydraulic conductivity range for the unconfined Sea Level Aquifer is 1×10^{-2} to 1 cm/sec (Table 3.1-1).

Groundwater Flow Rates in the Aquifers

A range of horizontal groundwater flow rates within the Water Table and Sea Level Aquifers is estimated using the Best Estimate Range of hydraulic conductivity values (Table 3.1-1), horizontal hydraulic gradient estimates developed from the April 1992 water table elevation contour map (Figure 3.1-4), and an assumed effective porosity of 0.25. The groundwater flow rates for each aquifer are estimated by applying Darcy’s Law of the form:

$$v = K I / n$$

where:

- v = average linear groundwater velocity in feet/day
- K = horizontal hydraulic conductivity in feet/day
- I = horizontal hydraulic gradient in feet/foot
- n = effective porosity (dimensionless)

Because of differences in hydraulic gradient across the Site, Darcy’s Law is applied between two points. The flow rates reported below apply between these points.

Water Table Aquifer

Using the April 1992 data (Figure 3.1-4), the hydraulic gradient between the 190-foot water table elevation contour and MW-23 north of Sequalitchew Creek (measured perpendicular to the contours) is approximately 0.05 foot/foot. For a range of hydraulic conductivity of 14 to 140 feet/day (5×10^{-3} to 5×10^{-2} cm/sec), the estimated groundwater flow rate between these two points is approximately 3 to 28 feet/day (approximately 1,000 to 10,000 feet/year).

South of the creek, the April 1992 hydraulic gradient is calculated to be approximately 0.02 foot/foot between three pairs of points: (1) between the 200-foot water table elevation contour and MW-21, (2) between Old Fort Lake and MW-17, and (3) between Old Fort Lake and MW-22 (Figure 3.1-4). Therefore, the estimated groundwater flow rate determined between these sets of points ranges from approximately 1 to 22 feet/day (approximately 400 to 8,200 feet/year) using the range of Water Table Aquifer K estimates.

As discussed above, water table elevations gradually dropped during the summer and autumn months, generally resulting in a flatter water table and slightly lower hydraulic gradients toward discharge points. The lower gradients (5 to 20 percent lower in December than April 1992) result in correspondingly lower groundwater velocities.

Unconfined Sea Level Aquifer

Because the gradient flattens abruptly west of the “Cutoff”, gradients and resulting groundwater flow rates were calculated between MW-3 and Puget Sound (assumed aquifer discharge at elevation 0 msl), and between MW-6 and Puget Sound. The hydraulic conductivity range of 1×10^{-2} to 1 cm/sec (28 to 2,800 feet/day) was used for the groundwater flow rate estimates (Table 3.1-1).

Using April 1992 data, a gradient of 0.005 foot/foot is calculated between MW-3 and Puget Sound, resulting in estimated groundwater flow rates ranging from approximately 0.6 to 60 feet/day (approximately 200 to 20,000 feet/year). For a gradient of 0.02 foot/foot calculated between MW-6 and Puget Sound, flow rates range from approximately 2 to 200 feet/day (approximately 800 to 80,000 feet/year). Consistent with the Water Table Aquifer, estimated groundwater velocities in the Unconfined Sea Level Aquifer were typically 5 to 20 percent lower in December 1992 than in April 1992, due to lower gradients.

Semiconfined Sea Level Aquifer

The groundwater flow rate in the semiconfined Sea Level Aquifer is estimated between MW-18 and Puget Sound. The water table elevation in MW-18 was 5.07 feet msl in the April 1992 round of measurements, resulting in a gradient toward Puget Sound of 0.003 foot/foot. Therefore, a range of groundwater flow rates of approximately 0.3 to 2 feet/day (approximately 120 to 600 feet/year) are estimated using the range of K estimates for the Sea Level Aquifer presented in Table 3.1-1. Estimated groundwater velocities in the semiconfined Sea Level Aquifer were approximately 10 percent lower in December 1992 than in April 1992 because of lower gradients.

However, because groundwater discharges from the semiconfined Sea Level Aquifer into the unconfined Sea Level Aquifer across most of the Site (except along the southwest corner in the vicinity of MW-17), groundwater flow rates calculated between MW-18 and Puget Sound may not be representative of gradients encountered east (upgradient) of the “Cutoff”.

A second range of flow rates for the Sea Level Aquifer is estimated on a more regional scale by applying Darcy’s Law between Bell Hill No. 1 and MW-18, a distance of approximately 10,000 feet. This estimate accounts for the change from confined to unconfined conditions within the aquifer. The water level elevation in Bell Hill No. 1 is approximately 75 feet msl, resulting in an average regional gradient of approximately 0.007 foot/foot between it and MW-18. Applying the K range above results in groundwater flow rates ranging from approximately 0.8 to 4 feet/day (approximately 300 to 1,400 feet/year).

Estimate of Vertical Flow Through the Aquitard

Hydraulic Conductivity Testing of the Aquitard. Two undisturbed samples of the Kitsap Aquitard were collected and tested in Hart Crowser’s geotechnical laboratory using flexible-wall permeameter methods. A vertical hydraulic conductivity value of 8×10^{-7} cm/sec was obtained from laboratory testing of a sample of the aquitard material (MW-20, S-24). The first attempt to collect an undisturbed sample of the aquitard material (from MW-22) using a Shelby tube was unsuccessful. After the Shelby tube was driven into the very stiff silt (too stiff for the tube to be pushed), the pins attaching it to the drill rods snapped during the retrieval attempt. The Shelby

tube remained in the bottom of the borehole, preventing further sampling efforts. No cohesive soils suitable for laboratory K testing were encountered during drilling of MW-21.

Vertical Gradients

Stratigraphic and water level data from MW-18 in the Sea Level Aquifer beneath the Aquitard indicate that the aquifer is unconfined, with the water table more than 50 feet below the aquitard bottom. The vertical gradient across the aquitard is estimated by dividing the combined thickness of the Water Table Aquifer and Aquitard (assumed saturated) by the thickness of the aquitard. To be conservative, the thickness of the Water Table Aquifer observed at MW-20 (45 feet) is used rather than the thickness measured at MW-22 (less than 15 feet), closer to the “Cutoff”. Using this 45-foot aquifer thickness and the aquitard thickness observed in MW-18 (75 feet), a downward gradient of approximately 1.6 feet/foot across the aquitard is calculated.

Where the Sea Level Aquifer becomes confined farther to the east, the vertical gradient would be smaller. Therefore, the vertical gradient calculated from the existing data produces a “worst-case” (i.e., maximum) estimate of downward flow through the aquitard.

Rate of Downward Flow

The rate of downward flow across the Aquitard is estimated by applying Darcy’s Law, as defined above, vertically across the aquitard. Using the estimated downward gradient of 1.6 feet/foot, the geometric mean of the laboratory vertical K values (3×10^{-7} cm/sec = 0.3 feet/year), and an assumed porosity of 0.4 (rounded from 0.37 for stiff glacial clay from Terzaghi and Peck 1948), results in an estimated advective flow rate through the aquitard of approximately 1 foot/year.

3.1.3 Surface Water Features

Three surface water bodies (Puget Sound, Sequelitchew Creek, and Old Fort Lake) occur within or near the Site (Figure 3.1-1).

Puget Sound

Puget Sound borders the west boundary of the Burlington Northern Railroad property, which is below the bluff at the Site. Puget Sound directly or indirectly receives groundwater and surface water discharge from the Site vicinity.

Sequalitchew Creek

Sequalitchew Creek, which flows through the northern portion of Parcel 1 at the Site, originates in Sequelitchew Lake, approximately 1.4 miles to the east of the property. The creek flows westward through Hamer Marsh and Edmonds Marsh east of the Site before flowing within a steep-sided ravine that descends to Puget Sound. The Water Table Aquifer locally discharges into the creek via springs. The creek appears to provide some recharge to the unconfined Sea Level Aquifer in its lower reaches, as discussed above.

The upper and lower reaches of the stream are intermittent, becoming dry in the summer months. Visual observations indicate that during the dry season, when there is little freshwater flow in the lower reaches of Sequelitchew Creek, Puget Sound backs up into the creek valley at high tide.

The creek was also dry along the eastern margin of the Site (at staff gauge SG-5) between August 1992 and January 1993, indicating that the water table elevation was below the creek bottom. Water was typically observed in the creek 150 to 200 feet downstream of SG-5 during these dry months. Between staff gauges SG-4 and SG-2, the creek bed is below the water table elevation throughout the year; therefore, the creek maintains water in this stretch year round.

Old Fort Lake

Old Fort Lake is a small glacial kettle lake, which has no inlet or outlet. The shallow lake is fed by groundwater from the Water Table Aquifer, and the lake level is an expression of the water table. Data collected between April 1992 and July 1993 indicate that the lake level fluctuates seasonally approximately 8 feet.

3.2 GROUNDWATER QUALITY CHARACTERIZATION

3.2.1 Groundwater Sampling Conducted to Date

Site groundwater quality assessment began at the Site during the pre-RI site characterization with sampling of the three spring locations and seven surface water locations in December 1986. As part of the initial hydrologic and water quality assessment in late 1987 and early 1988, 17 monitoring wells were installed in the Water Table Aquifer (MW-7 through MW-14, and MW-17) and the Sea Level Aquifer (MW-1 through MW-6, MW-15, and MW-16).

Groundwater quality was evaluated in March 1988 by sampling and analysis of 15 monitoring wells, 3 springs, and 3 on-Site fire protection wells. During this first round of sampling, constituents identified in groundwater samples were detected at low concentrations, and a quarterly monitoring program was recommended to provide a basis to assess possible temporal or seasonal changes in groundwater quality. Three quarterly sampling rounds were conducted in June 1988, October 1988, and January 1989; results from these sampling rounds are summarized in Hart Crowser 1988c, 1988d, and 1989a, respectively.

Following installation of two additional monitoring wells (MW-18 and MW-19) in November 1989, interim sampling rounds were conducted in November 1989 (Hart Crowser 1990) and August 1990 (Hart Crowser 1991c).

Four additional monitoring wells (MW-20, MW-21, MW-24, and MW-27) were installed, followed by four quarterly groundwater and surface water sampling rounds in March, June, September, and December 1992. Twenty-seven monitoring wells, one spring discharging to Sequelitchew Creek, two sea-level seeps discharging to Puget Sound, and five surface water locations were sampled during the RI (35 combined groundwater and surface water locations). In addition, six off-Site wells were sampled to provide background groundwater quality data.

A supplementary sampling round was conducted in January 1993 to collect four sets of water quality data ("four usable data points" criterion discussed below). During this round, attempts were made to sample all groundwater and surface water sampling locations where four complete sets of water quality data had not been collected due to seasonally dry conditions.

In addition to groundwater sampling outlined in the Management Plan, quarterly groundwater sampling for DNT was continued from April 1993 through October 1997 at seven selected monitoring wells (MW-3, MW-6, MW-8, MW-15, MW-19, MW-22, and MW-27) and SEEP-1. In January 1996, two fireline wells (W-1 and W-2) were added to the quarterly sampling program. One additional fireline well (W-3) was sampled during two rounds.

After October 1997 and authorization from Ecology, the groundwater monitoring locations and frequency of sampling were reduced. Since then, three additional rounds of annual DNT groundwater sampling have occurred at four selected monitoring wells (MW-3, MW-6, MW-19, and MW-22) and fireline well W-2. The annual DNT groundwater sampling will be continued as required in the final CAP.

Table 3.2-1 summarizes groundwater sampling (by location) conducted to date.

Four Usable Data Points Criterion

As discussed in the Management Plan, the goal of the RI groundwater and surface water sampling program was to obtain four usable data points (adequate detection limits and sufficient data quality) for each target constituent identified in the RI/FS Management Plan at each of the 38 groundwater and surface water sampling locations. Both the pre-RI data and data collected during the RI were considered in determining the number of usable data points. During the first two rounds of RI water sampling, all locations were sampled for all target constituents. At the end of the two rounds, the existing pre-RI and RI data were evaluated to determine which locations required additional sampling for specific constituents.

As stated in the Management Plan, if seasonally dry conditions prevent the collection of an adequate number of samples (over five rounds of RI sampling) to achieve four usable points at each location, the available data would be evaluated to determine the necessity of additional sampling.

In general, four usable water quality data points for each target constituent were achieved at each sampling location, with the exception of some of the springs in the Sequatchew Creek valley, and monitoring wells completed in zones of seasonally (transient) perched water.

Although four usable data points were achieved after only two RI sampling rounds for some constituents (e.g., DNT and nitrate) at several locations, NAX and nitrate analyses were continued through the January 1993 sampling rounds to provide additional data for evaluating potential concentration trends over time. The subsequent quarterly sampling rounds beginning in April 1993 were also conducted for this purpose (NAX only). Table 3.2-2 presents the number of usable data points (analyses) for each constituent at each location collected over 32 rounds of combined pre-RI and RI water sampling covering 12 years (1988 through 2000).

RI Groundwater Quality Sampling Locations

Thirty locations were sampled during the pre-RI and RI for Parcel 1 inside the CDB (Figure 3.1-1):

- Twelve Water Table Aquifer monitoring wells (MW-7, MW-8, MW-9, MW-11, MW-12, MW-13, MW-14, MW-17, MW-20, MW-21, MW-22, and MW-24)

- Ten Sea Level Aquifer monitoring wells (MW-1, MW-2, MW-3, MW-4, MW-5, MW-6, MW-15, MW-16, MW-18, and MW-19)
- Two monitoring wells completed in zones of seasonal perched groundwater (MW-27 and 7-B-503)
- One spring discharging from the Water Table Aquifer to Sequalitchew Creek (SPR-4)
- Two seeps discharging from the Sea Level Aquifer to Puget Sound (SEEP 1 and SEEP 2)
- Three fire protection wells (W-1, W-2, and W-3)

Background Water Quality Sampling Locations

Two rounds of groundwater samples were collected from six locations outside the CDB to provide data for evaluation of natural background (upgradient) water quality for the Water Table Aquifer and Sea Level Aquifer. The background wells included City of DuPont Well No. 1, Bell Hill No. 1, Fort Lewis production wells FL-9 and FL-18, and two monitoring wells upgradient of Fort Lewis Landfill No. 5 (88-2-VD and 88-1-SS). City of DuPont Well No. 1, FL-9, and 88-2-VD are completed in the Water Table Aquifer; Bell Hill Well No. 1, FL-18, and 88-1-SS are completed in the Sea Level Aquifer. Available regional data indicate that the Water Table Aquifer and (semiconfined) Sea Level Aquifer at the background (upgradient) well locations are contiguous with these aquifers on the Site. As stated in Management Plan, the unconfined portion of the Sea Level Aquifer does not exist upgradient of the Site; background water quality in this aquifer is represented by both upgradient aquifers (Water Table and semiconfined Sea Level Aquifers). Background samples were collected in June and December 1992.

Constituent Analyses of Groundwater Samples

During the first two rounds of RI sampling, all on-Site groundwater samples were analyzed for the following constituents:

- Nitrate plus nitrite as nitrogen
- TPH (WTPH-418.1)
- Total priority pollutant metals plus aluminum (14 total metals)
- Dissolved priority pollutant metals plus aluminum (14 dissolved metals)
- PAHs
- NAX (TNT, 2,4-DNT, and 2,6-DNT and selected breakdown products including nitrobenzene [NB], 1,3-dinitrobenzene [DNB], and 1,3,5-trinitrobenzene [TNB])
- NG
- MMAN
- Total organic carbon (TOC)
- TDS
- Total suspended solids (TSS)

Selected monitoring wells were sampled and analyzed for OP and OC pesticides, PCBs, VOCs, and SVOCs.

Background water quality samples were analyzed for the following analytes: NAX, nitrate plus nitrite, total and dissolved metals, PAHs, TPH, TSS, TDS, and TOC.

3.2.2 Background Groundwater Quality Results

The following constituents were detected in one or more of the background water quality samples:

- Total and dissolved aluminum
- Dissolved antimony
- Total and dissolved cadmium
- Total and dissolved copper
- Total lead
- Total and dissolved zinc
- Nitrate
- Phenanthrene, a noncarcinogenic PAH (ncPAH)

As stated in the discussion of metals data for groundwater in Section 3.2.3, total metals concentrations are generally higher than dissolved metals concentrations in the same sample due to turbidity present in the unfiltered groundwater samples. The total metals concentrations in samples with elevated TSS do not appear to be representative of groundwater quality.

Background total aluminum detections occurred in samples with nondetectable or low concentrations of TSS. Dissolved aluminum was detected in 5 of the 12 background samples (filtered samples without turbidity). These data indicate that dissolved aluminum is a naturally occurring constituent of groundwater in the area. Aluminum-bearing minerals (such as feldspars and clay minerals) are common rock-forming minerals in the crust of the earth, and aluminum is naturally present at percent levels (greater than 10,000 mg/kg) in the glacial soils of Puget Sound (refer to Section 2.2 for area background soil quality results). As a result, aluminum is also naturally present in regional groundwaters.

During sample filtration, the filter contributed antimony to the dissolved metals samples; therefore, the antimony concentrations in the samples are not representative of groundwater quality, as discussed below.

3.2.3 Constituents in Groundwater

A discussion of the DNT and nitrate data for groundwater, and additional discussions of the metals and PAH data, are provided below. Groundwater quality data tables are provided in Appendix C.

DNT Data for Groundwater

The range of total DNT (2,4-DNT plus 2,6-DNT) concentrations detected since monitoring started in 1986 are as follows:

- MW-3 downgradient of Area 5 (0.07 to 0.56 µg/L)

- MW-6 downgradient of Area 26 (0.02 U to 0.44 µg/L)
- MW-8 downgradient of Area 31 (0.02 U to 0.21 µg/L)
- MW-15 downgradient of Area 5 (0.02 U to 0.16 µg/L)
- MW-19 downgradient of Area 18 (0.07 to 0.63 µg/L)
- MW-22 downgradient of Area 18 (0.05 to 0.87 µg/L)
- MW-27 completed in a zone of seasonally perched water beneath Area 18 (0.11 to 3.8 µg/L)

DNT has been detected only in monitoring wells located downgradient of areas where DNT has been detected in soils (Areas 5, 18, 26, and 31). DNT has not been detected in any other wells.

DNT has been detected in MW-15, but this concentration has not been confirmed in any of the six subsequent sampling rounds.

DNT site data collected since 1986 are summarized in Appendix C.

Evaluation of DNT Concentrations Related to Sample Turbidity

To evaluate potential differences in DNT concentrations between unfiltered samples and filtered samples, additional groundwater samples from two monitoring wells (MW-19 and MW-22) were collected in October 1992. Unfiltered and filtered (through a glass fiber filter) samples were submitted for NAX analyses. In addition, suspended particulate matter collected on the filter was submitted for NAX analysis.

The results of this evaluation indicate no significant difference between DNT concentrations in unfiltered and filtered samples (Appendix C). The measured differences in concentration can be attributed to sampling and analytical variability. Furthermore, no NAX compounds were detected in the filtrate (particulate matter trapped on the filter). These data indicate that DNT is present in the dissolved phase and that sample turbidity does not significantly affect detected DNT concentrations.

Area 18 Seasonally Perched Water

DNT has been detected in MW-27, a monitoring well located next to MW-22 (in Area 18) and completed in a localized zone of perched water that is present only during the wet season. When water was present in this monitoring well (to a maximum saturated thickness of less than 2 feet), the well bailed dry after removal of approximately one casing volume. The water level also recovered extremely slowly after purging (the perched zone occurs upon and within a relatively low-permeability till unit, as discussed in Section 3.1). Because the perched zone is incapable of yielding 0.5 gallon per minute (gpm) on a sustainable basis, it is not a potential drinking water source, in accordance with MTCA [WAC 173-340-720(2)(b)(i)].

SEEP 1

The SEEP 1 sampling location represents discharge to an intertidal beach area from a freshwater/saltwater mixing zone at the edge of the Sea Level Aquifer. Accordingly, the seep discharge is naturally saline (discussed in Section 3.1.2). During the period of monitoring, TDS measurements ranged from 9,600 to 16,000 mg/L, with an average value of 12,700 mg/L. Because TDS concentrations are greater than 10,000 mg/L, SEEP 1 is not a potential drinking water source, in accordance with MTCA [WAC 173-340-720 (2)(b)(ii)]. Similarly, other seeps

along the beach, which are also submerged daily by Puget Sound high tides, would not be considered potential drinking water sources (SEEP 2 north of Sequelitchew Creek has a similar range of TDS).

Total DNT concentrations from SEEP 1 have ranged from nondetection to 0.27 µg/L in the 25 samples collected over the period of monitoring (Appendix C). All detected DNT concentrations at SEEP 1 (pre-RI and RI) are at least 33 times lower than the protective surface water concentration of 9.1 µg/L. Based on this comparison, DNT discharging from Site groundwater via seeps to Puget Sound poses no concern to human health or the environment.

No Seasonal Trends in DNT Groundwater Concentrations

No seasonal trends are apparent in visual examination of the DNT groundwater quality data (Figures 3.2-1 through 3.2-4). Plots of DNT groundwater concentration as a function of groundwater elevation indicated no apparent correlation for any of the seven wells in which DNT has been detected at elevated concentrations (Figure 3.2-5). Groundwater elevation provides a more direct measure of seasonality than time of sampling (for example, April versus October) because groundwater elevations inherently account for recharge lag times, which will vary across the Site.

Summary of DNT Data for Groundwater

Data from 35 rounds of combined pre-RI and RI groundwater sampling at up to 30 locations (1986 through 2001) indicate consistently low DNT concentrations in 6 of 30 Site groundwater monitoring locations. DNT has been detected in groundwater samples from seven Site monitoring wells at marginally elevated concentrations. DNT has been detected only in monitoring wells located downgradient of areas where DNT has been detected at elevated concentrations in soils (Areas 5, 18, and 31). DNT groundwater concentrations do not show statistically significant increases or decreases at this time. The DNT groundwater concentrations may decline over time as a result of the ISR of DNT-containing soils. Because detected DNT concentrations were consistently low, are not affecting the regional aquifer, are not affecting surface water, and the aquifer is not used as a drinking water source, Ecology determined that “no active remedial action” was needed, and long-term monitoring at selected wells would be sufficient. This issue will also be addressed in the Cleanup Action Plan for the Site.

Nitrate Data for Groundwater

Nitrate (expressed as nitrogen) has been detected in monitoring wells MW-6, MW-13, and MW-22. MW-13 is located along the upgradient (eastern) edge of the Site. Elevated nitrate concentrations (e.g., 9.2 mg/L in October 1988) have also been detected at MW-14, also at the upgradient edge of the Site. These data suggest potential nitrate sources upgradient (east) of the Site, such as animal pasturing, which is known to have occurred east of the Site in the past. The nitrate data collected to date for groundwater are provided in Appendix C.

Elevated nitrate concentrations were detected in samples from wells MW-6 in March and April 1988, and MW-13 in March 1988. No nitrate concentrations from these wells have been elevated in any of eight subsequent rounds of monitoring, as shown in Figure 3.2-6. Regression

analyses on the nitrate data indicate that the downward trends at these two wells are statistically significant (95 percent confidence level; $p = 0.05$).

The nitrate concentrations detected in samples from MW-22 were at approximately 10 mg/L in the June, September, and December 1992 sampling rounds. These data suggest that the nondetection in the March 1992 sample from this well was erroneous, possibly due to sample mislabeling or analytical reporting error (Appendix C). No analytical problems with this result were indicated by full (Level IV) data validation.

Although elevated nitrate concentrations were detected in groundwater samples collected from two monitoring wells in 1988, concentrations in these wells show statistically significant declines. Because elevated nitrate concentrations have been detected in samples from monitoring wells located along the eastern (upgradient) edge of the Site, off-Site sources of nitrate are possible.

Metals Data for Groundwater

With the exception of aluminum, no concentrations of dissolved metals in any groundwater sample were elevated. Of 126 site groundwater samples from 10 wells analyzed for dissolved metals, 14 samples contained elevated concentrations of aluminum. As discussed above, 2 of the 12 background samples had dissolved aluminum concentrations above 0.05 mg/L, indicating that aluminum may be present at this concentration in regional background groundwater. Only 1 of the 126 groundwater samples had concentrations above 0.2 mg/L (0.98 mg/L at MW-8 in September 1992). This single detection appears to be anomalous since it is more than four times higher than any other detection in this well or any other well sampled during the RI.

Concentrations of some total metals (unfiltered samples) were elevated in groundwater samples from selected wells. For the pre-RI and RI data, dissolved concentrations are defined as being filtered through a 0.45- μ m filter in the field. All dissolved and total metals data for groundwater are provided in Appendix C.

The consistent difference between total and dissolved metals concentrations indicates that the metals concentrations are associated with particulate matter within the groundwater samples rather than dissolved in the groundwater; i.e., the total concentrations are an artifact of the well installation, development, and sampling methods (bailer use). The monitoring wells were installed in accordance with Chapter 173-160 WAC; however, they cannot be developed sufficiently to provide low-turbidity samples consistently across the Site. Therefore, in accordance with MTCA [WAC 173-340-720 (9)(b)], dissolved metals concentrations are a more representative measure of groundwater quality at the Site.

The following discussion provides a summary of analyses performed to assess the relationship of sample turbidity to detected total metals concentrations. These analyses support the conclusion that the detected total metals concentrations are biased high due to sample turbidity.

Correlation of Total Metals Concentrations and Suspended Sediment (Sample Turbidity)

There is a strong correlation between sample TSS and total metals concentrations in unfiltered groundwater samples collected during the RI. Figures 3.2-7 through 3.2-9 show plots of total metal concentration versus TSS for each metal with elevated detected total concentrations. Although outlier data points exist, the data plots indicate a strong correlation between metals

concentrations and sample turbidity (TSS). The figures also demonstrate that total metals concentrations generally are detected only in samples with elevated TSS (above 100 mg/L).

Calculations were performed using these data plots to estimate what concentrations (order-of-magnitude) in the particulate phase (TSS) would be necessary to produce the observed total metals concentration in the groundwater samples. These particulate concentrations are then compared to background soil quality data for the Site.

The equation used is as follows:

$$\text{particulate concentration (mg/kg)} = \frac{\text{concentration in water (mg/L)} \times 10^6 \text{ mg/kg}}{\text{TSS (mg/L)}}$$

This analysis assumes that the metals desorb completely from the particulate matter during sample digestion for metals analysis.

Regression analyses were conducted on the total aluminum and total lead data (versus TSS). The regression equations were used to calculate a representative TSS value for a given water concentration of interest. Using these water concentrations and calculated TSS values, corresponding particulate concentrations were estimated using the above equation. Note that the same general range of particulate concentrations can be calculated using an “eye-balled” best-fit line through the data, rather than a regression equation.

These calculations suggest that, at these TSS values in the groundwater samples, aluminum concentrations as high as 100 mg/L in water can be the result of particulate (soil) concentrations on the order of 30,000 mg/kg. This soil concentration is only slightly above the range of aluminum concentrations detected in the area background soil samples for the Site. Similarly for the other metals, this evaluation indicates groundwater concentrations could be the result of respective soil concentrations typical of background soils.

Although the numbers calculated using this simple evaluation are approximate, they demonstrate that high total metals concentrations in the groundwater samples can be caused by a high concentration of particulate matter (high TSS) with low concentrations of metals on the particulate matter.

Decreased Total Metals Concentrations Following Monitoring Well Redevelopment

Between the first and second rounds of RI water sampling, the newly installed Water Table Aquifer monitoring wells (MW-20, MW-21, MW-22, and MW-24) were redeveloped using a more vigorous method (air-lift pump) than that previously used (submersible pump) to remove as much turbidity as possible. As a result, concentrations of total metals in these wells generally decreased between the March and June sampling rounds, further supporting the contention that the observed total metals concentrations are the result of sample turbidity. TSS values were again higher in several wells in the September and December sampling rounds, resulting in corresponding increases in total metals concentrations. Although TSS and total metals concentrations varied over time, dissolved metals were consistently not detected in filtered groundwater samples.

Comparison of Monitoring Well and Production Well Construction/Development

Because they are constructed for different purposes, monitoring wells (as sampled in this RI) and production (water supply) wells are designed, constructed, and developed according to substantially different standards. As a result, the turbidity of groundwater collected from Site monitoring wells is not representative of groundwater that would be pumped from a properly installed production well in these same aquifer materials.

The principal purpose of a production well is to provide maximum yield with minimum turbidity, both to prevent the need for filtration and to protect the pump and piping from corrosion. For aesthetic reasons, drinking water supplies are not cloudy (turbid); in fact, a secondary drinking water standard exists for turbidity. To achieve this minimum turbidity, design of a production well is typically detailed, requiring evaluation of the sizing of the well screen and the filter pack (outside the screen) based on the characteristics of the aquifer materials. Construction of the wells includes large-diameter casings to accommodate pumps and increase yield, and often thick filter packs to prevent finer-grained aquifer materials from reaching the well screen. Development of these wells typically takes several days, often involving surging or other techniques. Development is typically completed during a pumping test in which the well is pumped at the expected rate of yield for an extended period (often 24 hours or more). The combination of the intensive development and high-volume pumping is generally successful at removing suspended sediment from the well and filter pack, resulting in water free of turbidity.

On the other hand, the principal purpose of a monitoring well is to provide a groundwater sample, which requires relatively small yield. As a result, the on-Site monitoring wells were constructed of 2-inch-diameter polyvinyl chloride (PVC) with up to 2 inches of filter pack outside the well screen, which is standard for the environmental industry and in accordance with state well construction regulations (Chapter 173-160 WAC). Because the wells have an inside diameter of less than 2 inches, the methods of development are limited. Submersible and air-lift pumps were used to develop the on-Site monitoring wells. However, these pumps were incapable of creating high enough water velocities at the well screen and filter pack to remove all the sediment. As a result, groundwater samples collected from the monitoring wells had varying levels of turbidity (measured as TSS).

As a result of the differences in design, construction, and development of the two types of wells, a production well would be capable of producing turbid-free water from the aquifers on the Site, whereas the monitoring wells are not.

Dissolved Antimony Related to Sample Filtration

Filters used in the collection of filtered groundwater and surface water samples for dissolved metals analyses contributed antimony to the filtered samples. Antimony was detected consistently in filtered groundwater and surface water samples from the Site, but not in unfiltered samples. This is the opposite of the typical situation discussed above, where total metals concentrations are substantially higher than dissolved concentrations due to sample turbidity. There is strong evidence (presented below) that the filters contributed antimony to the filtered water samples, and that antimony is not present at detectable concentrations in Site groundwater or surface water.

First, dissolved antimony was detected in 85 of 168 (51 percent) of the filtered water samples collected during the RI (including groundwater, surface water, field duplicates, and rinsate blanks consisting of deionized water), whereas total antimony was detected in only 2 of 168 (1 percent) of the unfiltered samples. The range of dissolved antimony concentrations was 0.005 to 0.019 mg/L, with an average of 0.008 mg/L (excluding one very turbid sample [7-B-503] from a zone of perched water, for which the dissolved concentration was 0.08 mg/L higher than the total concentration).

Second, a controlled experiment was conducted to evaluate potential antimony contributions from the materials used during water sample filtration. Because a water sample touched three different sampling materials during filtration in the field, each of the materials was tested individually. Samples of deionized water were passed through a length of polyethylene tubing alone and through a length of silicone tubing alone (both tubing materials are used with a peristaltic pump during sample filtration). A sample was then passed through the combined lengths of tubing and the same brand of 0.45- μ m filter used for all RI water sampling. In addition, a sample was filtered by the analytical laboratory (ATI) using a different brand of 0.45- μ m filter. One sample that did not touch any of the filtration materials was also analyzed as a control. Consistent with the field sampling, the samples touched no other materials (e.g., stainless steel funnel). The five samples were duplicated to verify the results (10 samples total). Of the 10 samples, antimony was detected only in the 2 duplicate samples (0.0078 and 0.018 mg/L) that passed through the type of filter used during the RI work.

Third, independent data from the filter manufacturer indicate that, in a test of one filter, antimony was detected at a low concentration in the initial water passed through the filter, but not after 1 hour of passing water through it. This information suggests that antimony is present at trace concentrations in the filter membrane or housing material and that the antimony is flushed out of the filter with time. Typically in the field, approximately 0.5 liter of water was passed through the filter prior to sample collection. Differences in the volume of water purged through the filter prior to sampling may account for differences in the detected antimony concentrations in the filtered samples. For the controlled experiment, approximately 0.5 liter was also purged prior to sampling; the sample bottles (original and duplicate) were then filled one-half full and then full, alternating between bottles. The differences in duplicate results from the controlled experiment may also indicate decreases in concentrations as more water was passed through the filter.

These combined findings confirm that the detected concentrations of dissolved antimony in the RI water samples are the result of sample filtration and are not representative of Site groundwater and surface water quality. Consequently, the total antimony concentrations are more representative of the Site groundwater and surface water data.

Seep Data

Dissolved copper was the only metal detected, and it was detected in fewer than half of the samples. Ambient surface water data for Puget Sound indicate that these detections are within the range of background concentrations for copper in saline waters like those encountered at the seeps. In addition, elevated copper concentrations were detected in Site soils at only one small location in Area 18; therefore, the Site does not represent a potential source of copper to the seeps.

Summary of Metals Data in Groundwater

With the exception of aluminum, no dissolved metals concentrations in groundwater samples were elevated. Dissolved aluminum was also detected in background groundwater samples and in background soil samples (greater than 10,000 mg/kg [1 percent]), indicating that aluminum is a natural constituent in regional soil and groundwater. Total metals concentrations detected in unfiltered groundwater samples are a result of sample turbidity and therefore are not representative of groundwater quality.

PAH Data for Groundwater

During the RI, 129 groundwater samples were collected and analyzed for PAHs. During the September 1992 sampling round, one of two samples collected from MW-8 contained a total cPAH concentration of 1.56 µg/L. However, this result was not confirmed by the field duplicate sample collected concurrently from MW-8, which had a detected total cPAH concentration of 0.01 µg/L. Concentrations of cPAHs were not detected in groundwater samples or field duplicates from MW-8 in any of the other RI sampling rounds, either before or after the September 1992 round. Furthermore, detected total cPAH concentrations have not exceeded 0.1 µg/L in other groundwater samples collected during the RI. Therefore, based on the available data, the single unconfirmed elevated detection of total cPAH in MW-8 is not considered representative of groundwater quality at this location or elsewhere at the Site.

The only cPAH compound detected in more than 2 percent of groundwater samples collected during the RI was chrysene. Excluding the anomalous September 1992 groundwater sample from MW-8, frequencies of detection for cPAHs in RI groundwater samples are as follows:

- Benzo(a)anthracene: 0/128 (0 percent)
- Benzo(a)pyrene: 0/128 (0 percent)
- Benzo(b)fluoranthene: 2/128 (<2 percent)
- Benzo(k)fluoranthene: 0/128 (0 percent)
- Chrysene: 15/128 (<12 percent)
- Dibenzo(a,h)anthracene: 1/128 (<1 percent)
- Ideno(1,2,3-c,d)pyrene: 0/128 (0 percent)

Because chrysene is the only cPAH compound confirmed in Site groundwater, one-half the detection limit for chrysene was used in calculating total cPAH concentrations for groundwater samples where chrysene was not detected. One-half detection limits were not added for the other cPAH compounds because the data indicate that they were not present in Site groundwater.

Chrysene has been detected inconsistently in groundwater samples from 11 monitoring wells (excluding the September 1992 sample from MW-8) at marginally elevated levels. The chrysene detections occur infrequently in different monitoring wells, including well MW-14 located along the eastern (hydraulically upgradient) edge of the Site. The detected concentrations are very low, ranging from 0.02 to 0.1 µg/L, with an average of 0.03 µg/L relative to the detection limit of 0.01 µg/L. Furthermore, chrysene is not detected consistently at a given well over time (detected in only 1 of the 11 wells in more than 1 of the 4 sampling rounds). Statistical testing (a Fisher's Exact Test) indicates that the proportion of chrysene detections in on-Site monitoring wells (16/129) is not significantly different (at $p = 0.05$; 95 percent confidence level) than the proportion of detections in background wells (0/12).

Benzo(b)fluoranthene and dibenzo(a,h)anthracene were also each detected in one groundwater sample (other than the September 1992 sample from MW-8) at marginally elevated concentrations.

Pre-RI Data

PAHs were detected in some pre-RI groundwater samples collected from newly installed monitoring wells, and the concentrations generally decreased or were not detected in samples from subsequent rounds. These data may indicate potential hydrocarbon contributions from the air rotary drilling method (e.g., compressed air), which was used for installation of pre-RI and RI monitoring wells.

To evaluate potential hydrocarbon contributions during the drilling of the RI monitoring wells, a sample of particulate matter entrained in the compressed air discharging from the air rotary drill bit was collected on a quartz-fiber filter. Air was discharged onto the filter at normal operational pressures for approximately 10 minutes. Following the air discharge, a second filter was set on the drill rig, which was shut off, for 10 minutes to serve as a blank for evaluating ambient conditions. The samples were analyzed for TPH and PAHs to determine constituent mass added to the filter. Because a volume of air was not measured during this test, the sampling results were reported as mass, not a concentration.

TPH was not detected in either sample. One ncPAH (fluoranthene) was measured at 4.41 μg in the sample of discharged air and at 2.64 μg in the blank sample. These data suggest that the air rotary method did not introduce a significant quantity of hydrocarbons to the borehole.

However, the pre-RI wells were drilled (4 years earlier) using an older model drill rig, which may not have had as sophisticated an oil-trap system for the compressed air as the rig used and tested during the RI drilling.

Summary of cPAH Data for Groundwater

Although chrysene has been detected inconsistently in RI groundwater samples, no cPAH concentrations were detected at elevated concentrations (excluding one anomalous, unconfirmed sample concentration).

3.2.4 No Active Remedial Action Required for Groundwater

Based on these data, Ecology provided a “No Active Remedial Action” letter (Ecology 1996a) for cleanup in groundwater at the Site indicating that no constituents detected in Site groundwater required active cleanup or any further action except for the long-term monitoring of DNT in selected groundwater wells (Ecology 1996a). The duration of long-term groundwater monitoring for DNT will be specified in the Parcel 1 CAP.

SECTION FOUR Surface Water and Freshwater Sediment Characterization

This section presents the findings of the RI surface water and freshwater sediment characterization efforts within the CDB at the Site. The purpose of the surface water and freshwater sediment characterization was to evaluate constituent concentrations in these media. Surface water and sediment sampling and analysis were conducted in the two freshwater bodies on the Site—Old Fort Lake and Sequalitchew Creek. The physical nature of the lake and creek are discussed in Section 3.1.3. Sections 4.1 through 4.4 present specific information on surface water and freshwater sediment sampling and analysis. Appendix C presents supporting tables on surface water and freshwater sediment quality.

4.1 SURFACE WATER AND FRESHWATER SEDIMENT SAMPLING

In December 1986, five surface water/sediment sampling locations were selected for Parcel 1 within the CDB on the Site (Figure 4.1-1). These sampling locations were generally situated to intercept drainage from Site areas identified during the pre-RI work and to provide data regarding potential constituent migration along these pathways. The sampling locations included two locations along Sequalitchew Creek (SW-3 and SW-4) and three locations in Old Fort Lake (SW-5, SW-6, and SW-7). Note that SW-4 represents an upstream creek sampling location because it lies slightly outside the easternmost edge of the CDB. Therefore, SW-4 represents water quality entering the Site but is not influenced by Site activities.

4.1.1 Surface Water

Eleven rounds of surface water sampling were conducted at the Site between December 1986 and December 1992, concurrent with the groundwater sampling rounds. Sequalitchew Creek is intermittent in both its upper and lower reaches, remaining dry during the summer and autumn. As a result, samples from creek sampling location SW-4 could not be collected during all RI sampling rounds. Attempts to sample SW-4 in mid-January 1993 (RI Round 5) were unsuccessful because the creek remained dry at this location. A discussion of surface water sampling procedures is provided in Appendix A.

Consequently, the number of surface water sampling locations and the constituents analyzed for varied over time. The surface water results from the seven pre-RI sampling rounds are summarized in Hart Crowser (1987, 1988a, 1988c, 1988d, 1989a, 1990, and 1991c). Table 4.1-1 summarizes the number of usable data points for surface water (as defined in Section 3.2.1). The combined pre-RI and RI surface water data are discussed in the following subsections.

4.1.2 Freshwater Sediment

Three rounds of freshwater sediment samples have been collected from the Site. The first round of samples was collected in December 1986 as part of the pre-RI site characterization (Hart Crowser 1987). In this pre-RI round, samples were collected from locations SD-3 and SD-4 and SPR-4 in Sequalitchew Creek, and SD-5 and SD-6 in Old Fort Lake as shown in Figure 4.1-1. The freshwater sediment locations were sampled as part of the RI in March 1992, concurrent with RI Round 1 groundwater and surface water sampling. The RI sampling locations were the same as the pre-RI locations, except that SD-7 was added in Old Fort Lake and SPR-4 was not sampled in Sequalitchew Creek. A discussion of freshwater sediment sampling procedures is provided in Appendix A.

SECTION FOUR Surface Water and Freshwater Sediment Characterization

As recommended by Ecology, six additional Old Fort Lake sediment sampling locations (SD-501 through SD-506) were established and sampled in August 1993 (Figure 4.1-1). Sampling locations were defined using randomly selected locations within a 100-foot grid system. All locations are at least 50 feet from the July 1993 low water line. Two surface and subsurface composite samples were collected from each of the six locations at 0 to 2 cm and 2 to 15 cm. The 0- to 2-cm sample is representative of recent sedimentation/deposition material, whereas the 2- to 15-cm sample is representative of historical deposition within the assumed predominant biologically active zone (Ecology 1991c). Samples were analyzed for lead and submitted for grain size analysis. Samples were generally of fine-grained soils and organic material. Gravel was not observed at any sampling location.

4.2 SURFACE WATER QUALITY

Detected concentrations of analytes in surface water are discussed in this section. All RI surface water samples were analyzed for nitrate as nitrogen, TPH, 14 metals (total and dissolved), PAHs, NAX, NG, MMAN, TOC, TDS, and TSS. SVOCs were also analyzed in RI Round 1 (March 1992). Surface water quality data tables are provided in Appendix C.

4.2.1 Old Fort Lake Surface Water Quality

During four rounds of RI surface water sampling in Old Fort Lake, NAX, NG, MMAN, TPH, SVOCs, and VOCs were not detected. No concentrations of nitrate detected in Old Fort Lake samples were elevated. Over the full period of sampling in Old Fort Lake (pre-RI and RI), dissolved lead in 2 of 18 samples and dissolved copper in 6 of 12 samples were the only constituents detected at elevated concentrations. As discussed in Section 3.2.3, antimony was contributed to filtered groundwater and surface water samples during sample filtration; as a result, total antimony data are more representative of surface water quality.

Dissolved Lead Data for Old Fort Lake

Two of the 18 samples from Old Fort Lake that were analyzed for dissolved lead had elevated concentrations (0.006 mg/L at SW-6 in June 1988, and 0.004 mg/L at SW-7 in March 1992). Dissolved lead detections have not been confirmed at either sampling location in subsequent sampling rounds (five subsequent rounds at SW-6 and three rounds at SW-7).

Dissolved Copper Data for Old Fort Lake

Five of the 12 samples from Old Fort Lake that were analyzed for dissolved copper had elevated concentrations. The range of detected dissolved copper concentrations from the lake samples was 0.0052 to 0.010 mg/L. Elevated dissolved copper was detected at each of the three lake sampling locations in one or more of the RI sampling rounds.

4.2.2 Sequalitchew Creek Surface Water Quality

During the RI surface water sampling in Sequalitchew Creek, no NAX, NG, MMAN, TPH, SVOCs (other than common laboratory contaminants), or VOCs were detected. No concentrations of nitrate detected in Sequalitchew Creek samples were elevated. Over the full

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period of monitoring (pre-RI and RI), concentrations of dissolved lead, dissolved copper, total arsenic, and PAHs were elevated in one or more samples from the creek, as discussed below.

In the December 1986 sampling of Sequalitchew Creek, one or more of the OC pesticide compounds aldrin, endrin, and endrin ketone were detected at estimated concentrations below detection limits in samples from locations SW-3 and SW-4 (Hart Crowser 1987). Because these compounds were also detected in the laboratory preparation blank associated with these samples, the results are not confirmed as being representative of surface water quality. The only sample for which all three of these compounds were reported was from location SW-4, located upstream of the Site. The results of all soil and groundwater sampling conducted during the RI indicate that pesticides are not an indicator constituent at the Site.

Dissolved Lead Data for Sequalitchew Creek

Dissolved lead was detected at a concentration of 0.004 mg/L in one of three samples from background location SW-4. These data suggest that the detected dissolved lead may be related to off-Site sources to the creek, which extends almost 1.5 miles east of the Site. Dissolved lead has been detected at concentrations of 0.001 to 0.004 mg/L in regional rivers and streams (USGS 1987).

Dissolved Copper Data for Sequalitchew Creek

Five of the 11 samples from Sequalitchew Creek that were analyzed for dissolved copper had elevated concentrations. The range of detected dissolved copper concentrations from creek samples was 0.0077 to 0.14 mg/L. The 0.14 mg/L detection (SW-3 in March 1992) is anomalous because it is more than an order of magnitude higher than any other dissolved copper concentration detected in samples from either the creek or the lake, and because total copper was not detected in that sample.

Dissolved copper was also detected in one of the two samples from SW-4 located upstream of the Site, suggesting possible off-Site sources of dissolved copper to the creek. Dissolved copper is commonly detected in regional streams at concentrations of 0.001 to 0.005 mg/L, with reported detections as high as 0.048 mg/L (USGS 1987).

Dissolved lead and copper were occasionally detected in filtered samples at concentrations above corresponding total concentrations in unfiltered samples; these detections were not frequent. These results were not observed in deionized water rinsate blanks. Dissolved concentrations greater than corresponding total concentrations are attributed to sampling or analytical variability rather than contributions from the filter capsules used for sample filtration, as was the case for antimony (refer to Section 3.2.3).

The dissolved copper concentrations detected in Sequalitchew Creek are within the range of the background concentrations detected at the upstream location (SW-4), and within the range of regional background concentrations.

4.2.3 Summary of Surface Water Quality Data

Of the wide range of compounds for which on-Site surface water samples were analyzed, only dissolved lead and dissolved copper were detected at elevated concentrations in one or more

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samples from Old Fort Lake and Sequalitchew Creek. Dissolved copper was the only constituent with confirmed elevated detections. Dissolved lead was detected infrequently at marginally elevated concentrations in both Old Fort Lake and Sequalitchew Creek. None of the lead detections were confirmed in preceding or subsequent sampling rounds. In addition, the concentrations of dissolved copper and lead detected in on-Site surface water are within the range of background concentrations detected in an area background (upstream) sampling location in Sequalitchew Creek (SW-4). Concentrations of dissolved copper and lead detected in on-Site surface water are also within the range of background concentrations detected in other regional rivers and streams in Pierce County.

4.3 FRESHWATER SEDIMENT QUALITY

Analytes for the pre-RI sediment samples included antimony, lead, chromium, nitrates, PCBs, and OC pesticides. Analytes for the RI sampling included NAX, MMAN, NG, nitrate plus nitrite as nitrogen, priority pollutant metals (antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, mercury, manganese, nickel, selenium, silver, thallium, and zinc) plus aluminum, PCBs, OC pesticides, OP pesticides, PAHs, SVOCs, TPH, and TOC.

NAX, MMAN, NG, PCB, SVOCs, and TPH were not detected. OP pesticide data were rejected due to poor analytical method performance (see Appendix E). No OP pesticides were detected in soil or groundwater samples collected from the Site, and there is no record of historical use of OP pesticides. Freshwater sediment quality data tables are provided in Appendix C.

4.3.1 Old Fort Lake Freshwater Sediment Quality

PAHs, two OC pesticide, and metals were detected in sediment samples collected from Old Fort Lake. Total ncPAHs were detected in samples SD-5 (1.03 mg/kg) and SD-6 (0.60 mg/kg). Total cPAHs were detected in sample SD-5 (0.46 mg/kg).

Two OC pesticides (endosulfan sulfate and 4,4-DDE) were detected at low concentrations in all three sediment samples from Old Fort Lake. Similar to surface water results, these compounds were detected in laboratory blanks, thereby indicating that these detections are not representative of sediment quality.

Old Fort Lake sediment sampling results indicated no elevated concentrations of metals except cadmium and lead. No data were available for aluminum, antimony, beryllium, silver, mercury, and thallium.

Detected concentrations of lead in RI samples ranged from nondetection to 180 mg/kg (SD-5). August 1993 RI sample concentrations in the 0- to 2-cm samples ranged from 69 to 170 mg/kg. Concentrations in the 2- to 15-cm samples ranged from nondetection at 19 to 43 mg/kg. No freshwater sediment lead concentrations were elevated.

4.3.2 Sequalitchew Creek Freshwater Sediment Quality

Two OC pesticides and metals were detected in sediment samples collected from Sequalitchew Creek. Similar to Sequalitchew Creek surface water results, the pre-RI sediment samples from locations SD-3 and SD-4 contained estimated concentrations (below detection limits) of OC pesticides, including gamma-BHC, dieldrin, endrin, 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT (Hart

SECTION FOUR Surface Water and Freshwater Sediment Characterization

Crowser 1987). However, like the surface water detections, each of these compounds was also detected in laboratory blanks, thereby indicating that the detections are not representative of sediment quality.

No results from Sequalitchew Creek were elevated for aluminum, antimony, arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc. Beryllium, selenium, and thallium were not detected.

4.3.3 Summary of Freshwater Sediment Quality

Of the wide range of constituents for which freshwater sediment samples were analyzed, no constituents were detected at elevated concentrations. There are no published freshwater sediment criteria/standards for Washington State. The freshwater sediment data were compared to standards developed by the State of Wisconsin and the Ontario Province of Canada. These standards were deemed to be the most relevant for the Site. Lead was detected in Old Fort Lake sediments but at relatively low concentrations. Detected concentrations of metals were comparable to available background sediment data for the Puget Sound region.

4.4 NO FURTHER ACTION FOR SURFACE WATER OR FRESHWATER SEDIMENTS

Based on these data, Ecology provided verbal agreement that No Further Action was required for surface water or freshwater sediment at the Site (pending the submittal of a summary of the data), thereby indicating that no constituents detected in Site surface water or freshwater sediment required cleanup or any further action (Ecology 1996d).

Note that although additional groundwater samples (collected at spring locations), surface water and freshwater sediment samples (Sequalitchew Creek), and marine sediment samples (Puget Sound) were collected for characterization purposes, these data are reported in a separate document because the locations from which they were collected are outside the CDB for the Site.

- Anderson, W.W., A.O. Ness, and A.C. Anderson. 1955. Soil Survey of Pierce County, Washington. U.S. Department of Agriculture Soil Survey Report, Series 1939, No. 27.
- Associated Earth Sciences. 1984. Geohydrology Study, Pump Tests, DuPont Planning Area, DuPont, Washington.
- Borden, R.K. and K.G. Troost. 2001. Late Pleistocene Stratigraphy in the South-Central Puget Lowland, Pierce County, Washington. (Washington Division of Geology and Earth Resources Report of Investigations 33.
- Boyce, C.P. and T.C. Michelsen. 1993. Cleanup standards for petroleum hydrocarbons. Part 2. Case study comparisons of site-specific cleanup standards with generic TPH standards. *Jour. Soil Contamination*, v. 2, p. 265-280.
- Ecology, Washington State Department of. 1991. Sediment Cleanup Standards - User Manual. Washington State Department of Ecology, Sediment Management Unit. December.
- . 1993a. Letter from Mike Blum to Vern Moore/Weyerhaeuser Company and Jack Frazier/The DuPont Company Regarding Area 20 USTs. April 12.
- . 1993b. Letter from Mike Blum to Vern Moore/Weyerhaeuser Company and Jack Frazier/The DuPont Company Regarding Area 38 UST. May 6.
- . 1993c. Letter from Mike Blum to Vern Moore/Weyerhaeuser Company and Jack Frazier/The DuPont Company Regarding Area 39 UST. May 6.
- . 1994. Natural Background Soil Metal Concentrations in Washington State. Publication 94-115.
- . 1996a. Letter from Mike Blum to Vern Moore/Weyerhaeuser Company and Jack Frazier/The DuPont Company. January 12.
- . 1996b. Letter from Mike Blum to Vern Moore/Weyerhaeuser Company and Jack Frazier/The DuPont Company. June 12.
- . 1996c. Letter from Mike Blum to Vern Moore/Weyerhaeuser Company and Jack Frazier/The DuPont Company. October 9.
- . 1996d. Personal Communication from Mike Blum to Vern Moore/Weyerhaeuser Company regarding Russ MacMillan's June 14, 1996 Draft Parcel 2 Cleanup Action Plan comments during Parcel 2 CAP Meeting. June 26, 1996.
- . 1998. Interim Groundwater Quality Monitoring for DNT. Memorandum.
- . 2001. Model Toxics Control Act Cleanup Regulation. Chapter 173-340 WAC. Feb. 12, 2001. Ecology Publication 94-06.
- Freeze, R.A., and J.A. Cherry. 1979. Groundwater. Prentice-Hall, Inc. 604 p.
- Harper-Owes. 1985. Background Water and Soil Quality at the Pilchuck Tree Farm Demonstration Site, 1982-1984. Final Report Submitted to Municipality of Metropolitan Seattle. December 1985.
- Hart Crowser, Inc. 1976. Preliminary soils and foundation investigation proposed DuPont marine terminal, DuPont, Washington. Report to Weyerhaeuser Company, Transportation Department, Tacoma, Washington.

- . 1986. Phase I Site Survey and Review Weyerhaeuser/DuPont Property, DuPont, Washington. September 1986.
- . 1987. Site Characterization Report, Phase II Sampling and Analysis, Former DuPont Works Site, DuPont, Washington. August 10, 1987.
- . 1988a. Hydrologic and Water Quality Assessment, Former DuPont Works Site, DuPont, Washington. May 13, 1988.
- . 1988b. Hydrogeologic Report - Bell Hill Well No. 1, Weyerhaeuser Real Estate Company, DuPont, Washington. Prepared for Weyerhaeuser Real Estate Company. October 1988.
- . 1988c. Summary of Results of June 1988 Groundwater Sampling, Former DuPont Works Site, DuPont, Washington. Letter to Weyerhaeuser, Attn: Rudy Thut. September 9, 1988.
- . 1988d. Summary of Results of October 1988 Groundwater Sampling, Former DuPont Works Site, DuPont, Washington. Letter to Weyerhaeuser, Attn: Rudy Thut. November 18, 1988.
- . 1989a. Summary of Results of January 1989 Groundwater Sampling, Former DuPont Works Site, DuPont, Washington. Letter to Weyerhaeuser, Attn: Rudy Thut. February 28, 1989.
- . 1990. Summary of Results of November 1989 Groundwater Sampling, Former DuPont Works Site, DuPont, Washington. Letter to Weyerhaeuser, Attn: Rudy Thut. January 18, 1990.
- . 1991a. Final Remedial Investigation/Feasibility Study Report, Volume I. Site A Naval Submarine Base, Bangor, Washington. Prepared for Engineering Field Activity, Northwest, Silverdale, Washington. August 1, 1991.
- . 1991b. Final Report, Former Black Powder Production Area, Former DuPont Works Site, DuPont, Washington. October 4, 1991.
- . 1991c. Summary of Results of August 1990 Groundwater Sampling, Former DuPont Works Site, DuPont, Washington. April 3, 1991.
- . 1991d. Underground Storage Tank Removal and Verification of Closure, Areas 20A and 20B, Former DuPont Works Site, DuPont, Washington. October 16, 1991.
- . 1991e. Upper Powerhouse Stack Debris Characterization, Demolition, and Disposal Report. Former DuPont Works Site, DuPont, Washington. September 27, 1991.
- . 1992a. Management Plan for Remedial Investigation/Feasibility Study (RI/FS), Former DuPont Works Site, DuPont, Washington. January 17, 1992.
- . 1992b. Addendum to Management Plan for Remedial Investigation/Feasibility Study (RI/FS), Former DuPont Works Site, DuPont, Washington. May 15, 1992.
- . 1992c. Technical Memorandum, Results of EM-34 Survey, Kitsap Cutoff, Former DuPont Works Site, DuPont, Washington. February 21, 1992.
- . 1992d. Remedial Investigation, Phase I Soil Sampling and Analysis, Three Kettle Areas, Former DuPont Works Site, DuPont, Washington, June 5, 1992.

- . 1992e. RI Deliverable I, Remedial Investigation/Feasibility Study, Former DuPont Works Site, DuPont, Washington. October 7, 1992.
- . 1992f. Soil Sampling and Analytical Results, Underground Storage Tank (UST) Removal and Closure Results, Area 38, Former DuPont Works Site, DuPont, Washington. October 8, 1992.
- . 1992g. Soil Sampling and Analytical Results, Underground Storage Tank (UST) Removal and Closure Results, Area 39, Former DuPont Works Site, DuPont, Washington. October 8, 1992.
- . 1992h. Technical Scope of Work: Lead Abatement of Powerhouses. Former DuPont Works Site, DuPont, Washington. March 6, 1992.
- . 1993a. Final Report, Above-Ground Storage Tank Diesel Spill, Area 20B. Former DuPont Works Site, DuPont, Washington. March 18, 1993.
- . 1993b. Interim Status Memorandum, Area 18 (Sympathetic Detonation). Former DuPont Works Site, DuPont, Washington. October 4, 1993.
- . 1993c. Interim Status Memorandum, Area 19A (Paint Shop) and 19B (Oil House). Former DuPont Works Site, DuPont, Washington. October 4, 1993.
- . 1993d. Interim Status Memorandum, Area 30 Railroad Debris Area. Former DuPont Works Site, DuPont, Washington. October 4, 1993.
- . 1993e. Interim Status Memorandum, Area 31 Ravine. Former DuPont Works Site, DuPont, Washington. October 4, 1993.
- . 1993f. Interim Status Memorandum, Area 36 Lead Melt House. Former DuPont Works Site, DuPont, Washington. October 4, 1993.
- . 1993g. Interim Status Memorandum, Area 39 Laboratory. Former DuPont Works Site, DuPont, Washington. October 4, 1993.
- . 1993h. Interim Status Memorandum, Areas 18S, 19C, and 31 Inorganic Solid Debris. Former DuPont Works Site, DuPont, Washington. December 22, 1993.
- . 1994a. Interim Status Memorandum, Areas 10, 18, 25, and 31 DNT Soil Interim Source Removal. Former DuPont Works Site, DuPont, Washington. February 7, 1994.
- . 1994b. Interim Status Memorandum, Area 8 Pipeline and Former Above-Ground Storage Tanks. Former DuPont Works Site, DuPont, Washington. February 7, 1994.
- . 1994c. Interim Source Removal Status. Drum Disposal Areas, Areas 5 and 6. Former DuPont Works Site, DuPont, Washington. March 14, 1994.
- . 1994d. Draft Remedial Investigation (Volumes 1 and 2). Former DuPont Works Site, DuPont, Washington. December 22, 1994.
- . 1994e. Draft Risk Assessment. Former DuPont Works Site, DuPont, Washington. December 16, 1994.
- . 1994f. Draft Feasibility Study. Former DuPont Works Site, DuPont, Washington. December 23, 1994.

- METRO. 1985. Summary Statistics for Background Forest Soils, including Pilchuck Tree Farm, Pack Forest, Edmonds Community College, and King County Section 24.
- Noble, J.B. 1990. Proposed Revision of Nomenclature for the Pleistocene Stratigraphy of Coastal Pierce County, Washington. Washington State Division of Geology and Earth Resources Open File Report 90-4. February 1990.
- Pentec. 1992. Draft Environmental Impact Statement. Pioneer Aggregates Mining Facility and Reclamation Plan. January 2, 1992.
- Pioneer Technologies Corporation. 2002. Electronic Database for the Former DuPont Works Site, DuPont, Washington. April 1, 2002.
- Shacklette, H.T., and J.G. Boerngen. 1984. Element Concentrations in Soils and Other Surficial Materials of the Conterminous United States. U.S. Geological Survey, U.S.G.S. Professional Paper 1270. United States Printing Office, Washington.
- U.S. Geological Survey (USGS). unpublished. Concentrations of Metals in Soils and Streambed Sediments, Soos Creek. 1987.
- . 1987. Water Quality in Lower Puyallup River Valley and Adjacent Uplands, Pierce County, Washington. Water Resources Investigations Report 86-4154. Tacoma, Washington, 1987.
- . unpublished. Summary statistics for concentrations of metals in soils for the State of Washington. Preliminary report for Washington State Department of Ecology.
- Walters, K.L., and G.E. Kimmel. 1968. Ground-Water Occurrence and Stratigraphy of Unconsolidated Deposits, Central Pierce County, Washington. Washington State Department of Water Resources/USGS Water Supply Bulletin No. 22.
- West Shore Corporation NW and Pioneer Technologies Corporation. 2000a. Hot Spot Interim Action Report, Former DuPont Works Site. October 4, 2000.
- . 2000b. Sand Laydown Area Interim Action Report, Former DuPont Works Site. November 16, 2000.
- . 2001a. Interim Source Removal Actions: On-site Stockpiles Report, at the Former DuPont Works Site. January 4, 2001.
- . 2001b. 2001 Site Characterization Program: Sequelitchew Creek Canyon Narrow Gauge Railroad Bed, Parcel 1- Consent Decree at the Former DuPont Works Site. May 8, 2001.
- . 2001c. 2001 Site Characterization Program: Areas for Additional Sampling, Parcel 1- Consent Decree at the Former DuPont Works Site. June 5, 2001.
- . 2002a. Interim Source Removal Actions: Screening Plant Report, at the Former DuPont Works Site. January 22, 2002.
- . 2002b. Draft Interim Corrective Action Report: Foundations, Narrow Gauge Railroad and Hot Spots, Former DuPont Works Site. February 27, 2002.
- Woodward-Clyde Consultants. 1990. Draft Hydrogeology and Water Quality Technical Memorandum, Fort Lewis Landfill No. 5 Remedial Investigation/Feasibility Study. Submitted to the U.S. Army Corps of Engineers Seattle District. September 1990.

Appendix A

Field Procedures and Logs

The material in Appendix A was developed in draft form by Hart Crowser for the 1994 Draft RI (Hart Crowser 1994d). For completeness, it is retained here as it was developed. It includes references to all sampling conducted as specified in the RI/FS Management Plan (Hart Crowser 1992a). As a result, it refers to locations sampled outside the Consent Decree Boundary that will be the subject of additional reports.

Appendix B

Soil Quality Data

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Appendix B presents soil quality data representing current Site conditions as of September 2001. The tables are organized and labeled according to area as discussed in Section 2. The tables are in the same order as that in which they are discussed in Section 2—Site Areas (by number), AP Areas, Site Reference Area (REF), and Narrow-Gauge Railroad (NGRR). Refer to Section 2 for a complete description of each Site Area. Specific notes for the tables are as follows:

1. Blanks indicate no analysis for a specific constituent.
2. Soil quality data representing Site conditions as of September 2001 are provided in the tables, including pre-RI, RI, and interim source removal verification sampling results.
3. Data qualifiers include the following:
 - U Not detected at associated detection limit
 - J Estimated concentration
 - UJ Not detected; associated detection limit is an estimate
 - R Rejected data, as determined during data validation
 - S Sum of individual constituent concentrations (e.g., total cPAHs and total PCBs)
 - X Elution pattern does not match typical product
4. Field duplicate samples are designated with sample ID suffixes of D, DUP, or SSE (the different suffixes have identical meanings).
5. As discussed in Section 2 of the report, soil quality data from the following areas have been redesignated as follows:
 - Areas AP-A and AP-G have been included in the Areas of Potential Concern tables.
 - Areas AP-B and AP-D have been included in Area 26.
 - Samples designated AP-H at the time of sampling have been divided into Areas 25 and 26.
 - Sampling locations within 25 feet of a narrow-gauge railroad grade have been included in the Narrow-Gauge Railroad designation.

The redesignated soil quality data have been included in soil quality data tables in this appendix for the appropriate areas as listed above.

The tables were developed on the basis of information provided to URS in an analytical database submitted in final form for this RI on April 1, 2002 (Pioneer 2002).

Appendix C
Groundwater, Surface Water, and Freshwater Sediment Quality Data

Appendix C provides groundwater, surface water, and freshwater sediment quality data for the Site. Specific notes for the tables are as follows:

1. Blanks indicate no analysis for a specific constituent.
2. Data qualifiers include the following:
 - U Not detected at associated detection limit
 - J Estimated concentration
 - UJ Not detected; associated detection limit is an estimate
 - R Rejected data, as determined during data validation
 - S Sum of individual constituent concentrations (e.g., total cPAH and total PCBs)
3. Surface water sample ID suffixes include the month and year of sample collection (e.g., -3-88 sample ID suffix indicates sample collection in March 1988).
4. Field duplicate samples are designated with sample ID suffixes of D or DUP (these suffixes have identical meanings).

Groundwater Quality Data

Surface Water and Freshwater Sediment Quality Data

The following appendix material was developed in draft form by Hart Crowser for the 1994 Draft RI (Hart Crowser 1994d). For completeness, it is retained here as it was developed. It includes references to all sampling conducted as specified in the RI/FS Management Plan (Hart Crowser 1992a). As a result, it refers to locations sampled outside the Consent Decree Boundary that will be the subject of additional reports.

Appendix D
Laboratory Physical Soils Testing

This appendix material was developed in draft form by Hart Crowser for the 1994 Draft RI (Hart Crowser 1994d). For completeness, it is retained here as it was developed. It includes references to all sampling conducted as specified in the RI/FS Management Plan (Hart Crowser 1992a). As a result, it refers to locations sampled outside the Consent Decree Boundary that will be the subject of additional reports.

The Hart Crowser soils laboratory conducted mechanical (sieve) and hydrometer analyses to provide grain size distributions for aquifer and aquitard materials, respectively. In addition, flexible-wall permeability tests were conducted to estimate vertical hydraulic conductivity of the aquitard material.

Mechanical Analyses. The Hart Crowser soils laboratory conducted mechanical grain size analyses using standard sieve sizes in accordance with ASTM D 422. The wet sieve analyses were performed to determine the size distribution greater than the No. 200 mesh sieve. Figure 1 presents the classification system used for the grain size analyses. The results of the tests are presented as curves in Figures 2 through 12, plotting percent finer against grain size.

Hydrometer Analyses. Samples of the Kitsap Aquitard material were analyzed using the hydrometer method, or a combined analysis (mechanical plus hydrometer), to determine the size distribution smaller than the No. 200 mesh sieve (i.e., determine percent silt and percent clay). The hydrometer testing was conducted in accordance with ASTM D 422. The results of the tests are presented as curves in Figures 2 and 4.

Laboratory Vertical Hydraulic Conductivity Testing. Testing of vertical hydraulic conductivity was conducted on two undisturbed samples of the Kitsap Aquitard material.

The tests were performed in a triaxial cell using "flexible wall" permeameter techniques, which allowed application of confining stresses approximately equal to the in situ effective overburden stresses. The sample was oriented in its stratigraphically correct position (up versus down) and flow was directed vertically downward through the sample using falling head techniques. The tests were run until steady state conditions were established. The results of the vertical hydraulic conductivity testing are presented in Table 1.

Table 1
Summary of Laboratory Vertical Hydraulic
Conductivity (K) Results for Kitsap Aquitard Samples

Sample No.	Sample Description	Estimated Vertical K in cm/sec
MW-20, S-24E	Slightly clayey, sandy SILT	8×10^{-7}
MW-23, S-25A	Very sandy SILT with trace peat and sand partings	1×10^{-7}
Geometric Mean:		3×10^{-7} cm/sec

Appendix E

Data Quality Assessments

Recent Data Quality Assessment

Pre-1994 Data Quality Assessment

This appendix material was developed in draft form by Hart Crowser for the 1994 Draft RI (Hart Crowser 1994d). For completeness, it is retained here as it was developed. It includes references to all sampling conducted as specified in the RI/FS Management Plan (Hart Crowser 1992a). As a result, it refers to locations sampled outside the Consent Decree Boundary that will be the subject of additional reports.